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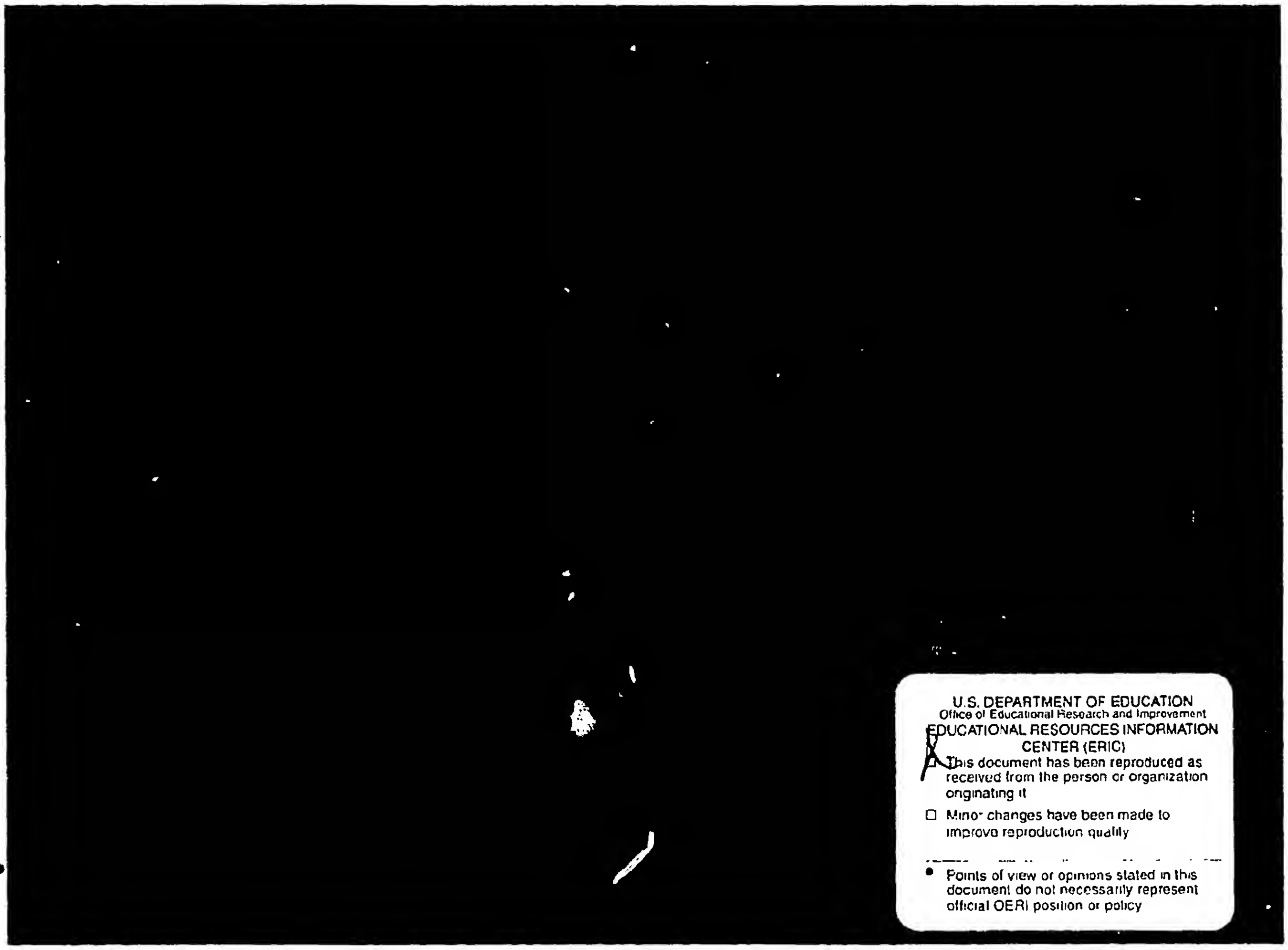
ABSTRACT

A specific nontraditional teacher preparation program for mid-career and second-career teachers is the focus of this monograph. The program, implemented at San Jose State University in California, is characterized from multiple perspectives as are the participants and the outcomes. Analysis of this single program and its outcomes illustrates how the traditional familiar route to teacher certification can be expanded and enhanced by facilitating the entry of scientists and mathematicians into teaching as a second career. Fourteen papers related to this topic are organized under two broad headings: (1) Second-Career Science and Mathematics Teachers; and (2) Case Studies. The appendix contains copies of the application materials for the program. (DDR)

Scientists and Mathematicians Become School Teachers

Billie F. Risacher, Editor



ERIC Clearinghouse for Science, Mathematics, and Environmental Education

Scientists and Mathematicians Become School Teachers

Billie F. Risacher
Editor

ERIC Clearinghouse for Science, Mathematics, and Environmental Education
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Part 1

Second-Career Science and Mathematics Teachers

Part 1

Second-Career Science and Mathematics Teachers

Preparing Scientists and Mathematicians for a Second Career in Teaching

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Mathematics, Science, and Technology Education
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How does one become a schoolteacher? The standard, familiar answer is that you go to college; complete a major or minor in the subject you want to teach; complete the required field experiences, including student teaching; apply to the state for certification; and search for a teaching position. Straightforward, it seems. In states and colleges where teacher certification programs are offered only at the graduate level, prospective teachers first need to complete an appropriate undergraduate degree before fulfilling certification requirements in graduate school, but the structure of the program is about the same. Students who decide late in their academic programs that they want to be schoolteachers simply complete the required courses as schedules permit and follow the traditional path. In reality, the standard "pipeline" into teaching has many openings, and it is relatively easy to move into and out of the pipeline as one progresses through undergraduate and graduate degree programs.

For those who leave college without teaching credentials, the pipeline to teaching remains open. Many graduates who decide that they would like to be teachers often take positions at private schools where state certification is not required. If they later decide to seek teaching positions in public schools, they take the college coursework that is required for certification and complete requirements as part-time students while retaining their teaching appointments. The experience gained as teachers in private schools will typically reduce the amount of clinical field experience required by the teacher preparation program and reduce the amount of time needed to complete certification requirements.

Despite the many variations of the standard route to teaching, there are often teacher shortages in certain subject areas like science and mathematics, or in certain geographic locations like inner cities and remote rural areas. In order to meet such variable needs, school districts and states occasionally develop emergency programs or apprenticeship programs that provide a fast track to teacher certification. These alternative programs typically enable college graduates to obtain certification without returning to college as full-time students for extensive coursework. For instance, an alternative program comprising an intensive summer institute of

six weeks followed by a one-year internship for science, mathematics, and foreign language teachers has been described by Hassard, Rawlings, and Giesel (1993). During the past several years, a wide variety of alternative certification programs have been developed to accommodate college graduates who did not prepare to teach while completing their academic programs. Feistrizer an Chester (1995) have provided a state-by-state analysis of these alternative certification programs.

The array of standard and alternative routes to teacher certification serve to attract qualified undergraduates and recent graduates into the teaching profession from a broad range of academic backgrounds and experiences. But what about mid-career or second-career individuals who have been away from college for several years, have gained considerable work experience in their chosen professions, and have subsequently decided that they would really like to be schoolteachers? Do the standard and alternative paths to teacher certification meet their needs? Several factors have contributed to increased interest in teaching among other professionals. including the downsizing that has become common in the corporate world and the slowdown in the growth of some industries. With the hope of attracting highly qualified individuals into teaching, some schools and teacher preparation programs have targeted recruiting efforts for such populations as military officers, retired engineers, technology specialists, and mid-management executives from the business world. Consequently, many have been attracted to teaching as an alternative to limited opportunities within their chosen professions, while others have decided to teach in response to the desire for a more meaningful or satisfying career. Indeed, in a recent study of second-career teachers, 45% indicated that they had "always wanted to teach" or teaching "would be a challenge" (Ludwig, Stapleton, & Goodrich, 1995). Another 35% said they entered teaching because they enjoy children, and 34% said they felt a social responsibility to become teachers. Unlike other nontraditional teacher preparation programs, those designed for mid-career and second-career professionals may be as rigorous in expectations and standards as traditional teacher preparation programs. These programs may, in fact, seem to be the same as traditional programs in terms of course requirements and field experiences. Their uniqueness typically lies in the nature of the target audience and a program structure that directly serves the needs of these students from the corporate sector.

When many alternative certification programs were first proposed, it was thought that ex-military employees and other retirees would be strongly represented among the new recruits, but mid-career professionals were also well represented among the participants (Darling-Hammond, Hudson, & Kirby, 1989). Though it is often asserted that the typical adult in American society will change careers several times during his or her working life, is the transition to teaching practical for those having long-term experiences in unrelated professions

or occupations? There are many valid reasons for facilitating mid-career or second-career transitions to teaching, from the educational ideal of enabling individuals to achieve their personal goals, to societal pressures associated with the changing economy and market forces. As the supply of new science and mathematics teachers fails to grow along with the increasing demand, the viability of programs serving mid-career and second-career transitions to teaching will likely become a greater concern.

By the year 2006, schools in the United States are projected to enroll 54.6 million students, a 10% increase over the number enrolled in 1994 (Hussar & Gerald, 1996). To keep pace, the teacher workforce will have to grow by over 325,000 teachers at a minimum. During the same period, projected large-scale retirements among baby-boomer teachers may exacerbate the teacher supply problem (Henke, Choy, Chen, Geis, Alt, & Broughman, 1997, p. 95). One indicator of potential teacher shortages is the extent to which school districts use some type of pay incentive to attract teachers to specific locations or roles. Though relatively few districts use pay incentives to attract teachers, 10% of public schools and 19% of private schools reported offering financial incentives during 1993-94. Among public schools, 3.2% offered incentives to mathematics teachers, 2.7% offered incentives to physical science teachers, and 2.8% offered incentives to life science teachers. For private schools, the percentages are 5.1, 3.9, and 3.6, respectively. The only teaching field for which incentives were more often offered was special education (6.2% of public schools, and 3.0% of private schools).

In addition to concerns about teacher shortages, however, there are concerns about the qualifications of teachers. Though teachers tend to be highly educated in comparison to the general U.S. population, with nearly all teachers having bachelor's degrees and about half having at least a master's degree (Choy, Henke, Alt, Medrich, & Bobbitt, 1993), there is often a mismatch between the academic backgrounds of teachers and their teaching assignments. In 1993-94, 39.5% of public school science teachers and 34.0% of public school mathematics teachers had neither an academic major nor minor in their main teaching field. The lack of qualifications in the main teaching field is even higher among teachers in private schools. More disturbing, nearly half of the teachers in schools having more than 40% low-income students had neither an academic major or minor in their main teaching field (Henke, Choy, Chen, Geis, Alt, & Broughman, 1997).

Another way to consider the issue of teacher qualifications is to ask how many students are being taught by under-qualified teachers. During 1990-91, about 25% of all public school students who enrolled in mathematics courses in grades 7-12 (4,124,000 of 15,510,000 students) were taught by teachers not having at least a minor in mathematics. During the same period, 39% of all public school students who enrolled in life science or biology courses in grades 7-12 (2,120,000 of 5,520,000 students) were taught by teachers not having at least a

minor in biology or related life science field. Finally, 56% of all public school students who enrolled in physical science classes in grades 7-12 (3,430,000 of 6,110,000 students) were taught by teachers not having at least a minor in physics, chemistry, geology, or earth science (Ingersoll & Gruber, 1996). These percentages rise to 33%, 45%, and 71% respectively when the analysis is restricted to high-poverty schools only. Similarly, these figures change to 36%, 38%, and 59% respectively when the analysis is restricted to high-minority schools. If one assumes the underlying premise that a qualified secondary school teacher will have at least an academic minor in the subject he or she teaches, then a disturbing percentage of American students are being taught science and mathematics by less-than-qualified teachers. Further, the proportion of less-than-qualified science and mathematics teachers in schools having high minority populations and students affected by poverty is more alarming; these are the students that need the most attention.

Much attention has been directed toward the issue of teacher preparation and certification during the recent years of reform in science and mathematics education. Both the *National Standards in Science Education* (National Research Council, 1996) and the *Curriculum and Evaluation Standards of School Mathematics* (National Council of Teachers of Mathematics, 1989) have significant implications for the preparation of teachers. Though there is a reluctance to specify the number of credit hours or specific courses to be required of prospective teachers, there is a high expectation that certified teachers have a strong knowledge base in mathematics and science education. The standards for professional development of teachers of science (National Research Council, 1996, p. 4), for instance, specify that teachers have sufficient knowledge in science to: (a) understand the nature of scientific inquiry and its central role in science; (b) understand fundamental facts and concepts; (c) make conceptual connections across science disciplines, mathematics, technology, and other school subjects; and (d) make use of scientific understanding to address personal and societal issues. This standard implies significant breadth of knowledge in science and mathematics as well as depth in a field of specialization. Concerns about the knowledge base that teachers must master led both the Holmes Group (1986) and the Carnegie Forum on Education and the Economy (1986) to recommend that prospective teachers acquire academic qualifications during their undergraduate years, and delay professional coursework in education until graduate school.

While the demand for qualified teachers in science and mathematics is on the rise, attrition rates among science and mathematics teachers is generally higher than the average for teachers overall. During 1993-94, there was an annual attrition rate of 6.9% among mathematics teachers, 6.7% among general/earth science teachers, and 8.6% among biology teachers (Whitener, Gruber, Lynch, Tingos, Perona, & Fondelier, 1997). These rates vary significantly from year to year, but this most recent survey found the attrition rate for biology

teachers to be higher than the rate for all other specialties, except among those assigned to teach mentally retarded students. In another study of teacher attrition, Shin (1995) also found science teachers to leave the profession earlier and more frequently than those teaching other subjects.

Additional concerns about teacher supply and demand relate to the increasing discrepancy between the proportions of minority school students and minority teachers (Henke, Geis, Giambattista, & Knepper, 1996). For instance, 16.3% of public school students are black, non-Hispanic, but only 8.6% of public school teachers are black, non-Hispanic. Similarly, 11.9% of students are Hispanic, but only 3.7% of teachers are Hispanic (Henke, Choy, Chen, Geis, Alt, & Broughman, 1997). Many believe that minority children become more motivated to learn and succeed when they see minority adults such as teachers who have achieved and been appointed to positions of responsibility. It is further suggested that minority teachers are more likely to implement culturally relevant instructional practices that promote achievement among minority students. Unfortunately, the proportion of minority teachers has remained stable (approximately 13%) between 1971 and 1991, while the proportion of minority school students increased by 8% between 1976 and 1990 (Henke, Geis, Giambattista, & Knepper, 1996).

In summary, there are several interacting factors influencing the supply of qualified science and mathematics teachers. At a time when student populations are growing, veteran teachers are aging and nearing retirement on a large scale. In mathematics and science particularly there are above average attrition rates, and many science and mathematics courses are currently taught by less-than-qualified teachers who are teaching out of their specialty areas. Finally, the distribution of science and mathematics teachers is uneven, with schools having large minority populations or high-poverty populations having the greatest need for qualified teachers. In short, the traditional and alternative routes to teacher certification are not keeping pace with the needs. One way of enhancing the science and mathematics teaching pool is to facilitate the transition of mid-career and second-career individuals with appropriate backgrounds into the teaching profession. Schools stand to benefit from scientists and mathematicians who choose to become teachers after years of experience in their chosen professions.

Though a relatively small percentage of school teachers obtain certification to teach after working in other occupations or professions, there are teacher preparation programs designed for the specific purpose of facilitating mid-career and second-career transition to teaching. There has been little formal examination of the preparation and characteristics of mid-career and second-career teachers, but several teacher preparation programs for nontraditional student populations have been described and evaluated. For example, Ludwig, Stapleton, and Goodrich (1995) studied the characteristics of viable programs and their impact on the supply

and demand of science and mathematics teachers. In their report, they present brief descriptions of several university and industry-based programs. Some of these programs are cohort-based and located within a university along with traditional programs, while others are individually developed with assistance from a university or school system. After meeting with the directors of many nontraditional certification programs, Ludwig, Stapleton, and Goodrich (1995, p. 11) noted an inherent difference of perspectives between mid-career students and teacher educators. Mid-career students want certification programs to be individualized and quick, while educators assume that mid-career students need the same program content as traditional students. Also, the older students in mid-career and second-career programs tend to: (a) have stronger, more confident voices than traditional students; (b) recognize inconsistencies in program requirements; (c) have strong beliefs about learning; and (d) surprisingly, seem more "fragile" than traditional students in their views of themselves as teachers and their expectations of the instructional setting. In response to these tendencies, many nontraditional certification programs have been tailored to the unique needs of second-career students and the external agencies they represent.

In this monograph, we focus on a specific nontraditional teacher preparation program for mid-career and second-career teachers and we try to characterize the program, the participants, and the outcomes from multiple perspectives. Rather than compare several programs for common features and levels of success in facilitating the transition of mathematicians and scientists into second careers as school teachers, we attempt to document in some detail the development of a program for nontraditional students, describe its unique features, and evaluate the program's impact. Through this analysis we hope to illustrate how the traditional, familiar route to teacher certification can be expanded and enhanced by facilitating the entry of scientists and mathematicians into teaching as a second career. Though such programs for nontraditional students may never constitute a major route to teacher certification, they have the potential to increase diversity in the teaching pool; facilitate professional mobility between teaching and other careers; be responsive to short-term, local needs for teachers in specific fields; and infuse new perspectives and practices into the existing ranks of science and mathematics teachers. In short, establishing teacher certification programs for practicing scientists and mathematicians can have a qualitative impact on the teaching workforce if not a significant quantitative impact.

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Traditional and Non-Traditional Pathways to Teaching: An Investigation of Pedagogical Content Knowledge

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Conceptual Framework

From the perspective of both teaching and learning, an examination of the factors that influence the acquisition of pedagogical content knowledge for different groups of prospective teachers is an important topic within the conceptual framework that deals with research on teaching (Brophy, 1991; Shulman, 1986). An examination of two groups of prospective teachers which are significantly different in subject-matter knowledge provides the opportunity to compare and contrast the two groups' belief structures and instructional strategies. In order to describe the relationship between teacher subject-matter knowledge and instructional practices, it is necessary to examine the knowledge teachers have about a particular mathematical topic. The mathematical topic, functions and graphs, was chosen for investigation because it is a major topic in the secondary curriculum and because a significant body of research concerned with students' understanding of functions and graphs has been completed (Leinhardt, Zaslavsky, & Stein, 1991). However, neither an investigation of subject-matter knowledge as a proxy for pedagogical content knowledge nor an investigation that considers beliefs alone can adequately address the complex nature of pedagogical content knowledge. This study links knowledge and beliefs by examining the influences of knowledge in the content area and beliefs about the learner and mathematics for two important groups - traditional undergraduates and post-graduate scientists and engineers. The following statement from Fennema and Franke (1992) provides a useful perspective with respect to an investigation of teachers' knowledge, beliefs, instructional practices, and the relationship between them.

> The transformation of knowledge in action is understandably complex. Little research is available that explains the relationship between components of knowledge as new knowledge develops in teaching nor is information available regarding the parameters of knowledge being transformed through teacher implementation. Here all aspects of teacher knowledge and beliefs come together and all must be considered to understand the whole. The challenge is

to develop methodologies and systemic studies that will provide information to enlighten our thinking in this area. The future lies in understanding the dynamic interaction between components of teacher knowledge and beliefs, the roles they play, and how the roles differ as teachers differ in the knowledge and beliefs they possess (p.163).

Pedagogical Content Knowledge

Shulman describes pedagogical content knowledge as the knowledge "which goes beyond knowledge of subject-matter per se to the dimension of subject-matter knowledge for teaching" (Shulman, 1986, p.9). He suggests that for a particular subject area such as mathematics, pedagogical content knowledge includes "the most useful representation of those ideas, the most powerful analogies, illustrations, examples, explanations, demonstrations - in a word the ways of representing and formatting the subject that make it comprehensible to others" (Shulman, 1986, p.10).

If Schulman's description is accurate, the questions concerning where pedagogical content knowledge comes from and what are its origins remain. As preservice teachers prepare for teaching and for making the transition from students to teachers, it is likely that they draw upon several sources of knowledge and beliefs. First, their own subject-matter knowledge will obviously play a significant part in their efforts to design lessons for students; but, it is reasonable to suppose that subject-matter knowledge will not completely determine the lessons. Teachers' beliefs about how students learn mathematics, their beliefs about mathematics itself, and their knowledge of teaching, in general, are likely to affect how they design and teach lessons. Two teachers who share similar subject-matter profiles may teach differently if they differ along these other dimensions.

Subject-Matter Knowledge

An investigation of prospective teachers' pedagogical content knowledge may be operationalized in the context of a specific content domain. Subject-matter knowledge of mathematics at the secondary level may be examined through a specific topic within the content domain. The mathematical topic functions, graphs, and graphing has received considerable attention of late (Leinhardt, Zaslavsky, & Stein, 1990). The content domain of function and graphs is important both from the perspective of being a central topic in the secondary curriculum and also from the perspective of serving as a site in which conceptual understanding is dependent on connecting different representational forms. In their comprehensive review of the research literature on "Functions, Graphs, and Graphing", Leinhardt, Zaslavsky, and Stein

(1990) suggest that the algebraic and graphical representations of functions are "two very different symbol systems that articulate in such a way as to jointly construct and define the mathematical concept of function" (Leinhardt et al., 1990, p.3). Within the content domain of functions and graphing there have emerged a number of studies which utilize research on students' thinking in this domain to investigate teachers' knowledge about the content and the learner (Even & Markovits, 1993; Even, 1993; Wilson, 1994). These studies suggest that this subject matter knowledge is an essential source of pedagogical content knowledge.

Knowledge of Students' Learning

In addition to viewing pedagogical content knowledge as the ability to represent and formulate subject-matter knowledge so that it is comprehensible to others, some researchers (Even & Markovits, 1993) also view pedagogical content knowledge as an understanding of what makes the learning of specific topics easy or difficult and the knowledge of conceptions and preconceptions that students of different ages and backgrounds bring with them to learning a specific topic. If this is the case, knowledge about students' learning as well as beliefs about learning will make a difference in their pedagogical content knowledge. Research (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989) suggests that, in some domains, teachers can use domain specific knowledge of children's learning to make specific instructional decisions, and thus, impact learning. These results emphasize the importance of teachers' knowledge about the learner in general (as a constructor of knowledge) and specifically (in a particular content domain) and how this knowledge has the potential to impact instruction and subsequently learning.

Beliefs about Learners and Learning Mathematics

The close association of cognitive psychology with research in the teaching and learning of mathematics has contributed extensively to the view of the learner in mathematics. Students are no longer viewed as "blank slates" but as active constructors of their own knowledge. The basic tenet that learners are active in structuring and inventing knowledge has important implications for teaching mathematics. Instruction cannot be viewed as the simple presentation, however carefully done, of the knowledge and skills to be acquired. Instruction must focus on the means to facilitate construction of mathematical knowledge (built on existing knowledge) through providing classroom settings in which students (learners) explore relationships, use those relationships as tools to solve problems, and communicate those findings with each other and the teacher. Because these two views are so different, it is reasonable to suppose that two teachers with similar subject-matter knowledge but different

beliefs about the learner and learning mathematics would engage in different instructional practices. Thus, the prospective teachers' beliefs about the learner and learning mathematics matter as we consider evidence of how potential sources of pedagogical content knowledge are reflected in the early simulations of instructional practice.

Beliefs about Mathematics

Beliefs about mathematics are particularly important because they may affect the form in which the concepts and skills are conveyed. Teachers who believe that mathematics is to be discovered and constructed by the students may design a lesson in which the students explore quantitative relationships initially by means of a table, then use a graphing calculator, and finally determine an algebraic representation of the solution. Teachers who believe that mathematics is a fixed body of knowledge to be transmitted may design quite a different lesson on the same topic. Cooney (1985) has argued that substantive changes in the teaching of mathematics such as those proposed by the current reform documents (NCTM's *Curriculum and Evaluation Standards for School Mathematics*, 1989) will be slow in coming and difficult to achieve because of the basic beliefs teachers hold about mathematics.

Methodology

Subjects and Setting

The subjects chosen for this study consist of two groups of prospective secondary mathematics students: (1) undergraduate mathematics majors and (2) post-graduate scientists and engineers, both enrolled in a methods for teaching mathematics course. The undergraduates (undergrads) were all full-time mathematics majors seeking either a B.A. or B.S. with a teaching credential. All of the undergraduates were in their early 20's and were enrolled in a traditional 3 credit Secondary Methods course at the University of Delaware. This course represents the capstone of their formal course work prior to student teaching. All of these students had taken the required education courses and most had fulfilled their mathematics requirements. Thus, they were familiar with educational theories of learning and some of the reform documents in mathematics education such as the *Curriculum and Evaluation Standards for School Mathematics* (1989).

The second group of students (Lab students) were from the Lawrence Livermore/San Jose State University teacher training program, a special part-time, off-campus program designed for them. These students were experienced professional research scientists, engineers, and mathematicians working full-time at the Laboratory and represented a range of ages from their 30's through their 50's. All of the Lab students possessed undergraduate degrees in

mathematics, computer science, engineering, or physics with 75% possessing a Master's Degree and 25% possessing a Ph.D. The Lab students were enrolled in the "methods course" which represented their initial experience in the teacher preparation program. Unless these students had read educational theory or some of the documents related to reform in mathematics and science education on their own, these ideas would be relatively new to them.

Tasks

Tasks were designed to assess different aspects of pedagogical content knowledge within the discipline of mathematics and the content area of functions and graphs. The areas are as follows:

1. *Subject-matter knowledge* was assessed through an analysis of their academic transcripts with respect to GPA and number of hours of course-work in mathematics, statistics, or computer science. In addition, all of the subjects were given a written assessment of subject-matter knowledge of functions and graphs.

2. *Beliefs* were assessed through a 32-item Likert scale which specifically addressed beliefs about the learner, learning mathematics, and mathematics itself.

3. *Instructional practices* were assessed through a vignettes task in which all of the subjects were asked to respond to student misconceptions and/or questions concerning major topics about functions and graphs - definition, notation and evaluation, composition, and inverse functions.

These tasks represent only a portion of the data that was collected for each group of prospective teachers, but were the data used in this paper to link knowledge and beliefs to potential instructional practices for the two groups.

Subject-Matter Knowledge: Task I

A written assessment of subject-matter knowledge in the content domain of functions and graphs was administered first and consisted of 15 multiple choice questions which may be categorized along the following three dimensions:

1. Interpretation or Construction
2. Initial Presentation
    a. Algebraic
    b. Graphical
3. Topic related to Functions and Graphs

a. Definition
b. Notation and Evaluation
c. Composition
d. Inverse Function

The tasks were those typical of a pre-calculus course and often included interpretation between graphical and algebraic representations. Several examples are as follows:

• Determine the domain of the function f(x) = 2x+3.

a. [-1,] b. [-3/2,] c. [0,] d. all real numbers e. none of these

• Determine which of the following graphs represents a function.

This task accomplished two objectives for the study: 1) it provided a means to categorize the subjects in order to choose cases for further analysis; and 2) it provided some initial information which could be used to report both consistencies and inconsistencies in subject-matter knowledge revealed in the instructional activities.

Beliefs Scale: Task II

As each course commenced, both groups were asked to complete a Beliefs Scale designed to assess their beliefs about the learner, learning mathematics, and mathematics itself. This scale, designed by one of the investigators, is a Likert scale based on views relevant to the teaching and learning of mathematics. They are listed below.

1. Beliefs about the learner (questions 1-8).
2. Beliefs about learning mathematics (questions 9-20).
    a. Representations
    b. Knowledge structures
    c. Connections between representations
3. Beliefs about mathematics (questions 21-32).
    a. Problem-solving
    b. Mathematizing
    c. Mathematical argument

The Beliefs Scale consists of eight questions designed to assess the view of the learner, 12 questions designed for each of the categories - view of learning mathematics and view of mathematics. It includes both positive and negative statements with respect to the reform goals in each area. For example, "Students should gain practice manipulating expressions and

practicing algorithms as a precursor to solving problems" as compared to "Problems and applications provide an excellent means to introduce new mathematical content." In the category "Beliefs about the Learner", beliefs could range from the view that students learn by remembering what they are taught to the view that students construct meaning as they learn mathematics. Thus, the results from the Beliefs Scale provide the opportunity to determine the prospective teachers' strongly-held beliefs for each of these categories and to assess how these beliefs are reflected in the early simulations of instructional practice. The Beliefs Scale was designed by the author and was based on a body of research on beliefs and on the Standards (NCTM, 1989).

Instructional Practices: Task III

A proxy for instructional practices was obtained by having the students react to students' conceptions and misconceptions of functions and graphs. In this task the subjects were presented with five classroom scenarios or vignettes describing student comments and were asked to describe how they would respond to the students in the situation. The content of each vignette represented a combination of the four topics related to the function concept described previously: definition, notation and evaluation, composition of functions, and inverse functions.

The first vignette was set in the context of a typical student misconception described in the literature concerning functions and graphs - picture-as-graph misconception. The student comments that the graph of the function (position vs. time of a projectile) is the same as a sketch of the path of the projectile. The subjects were asked to respond to the students' comments and offer (perhaps) some further explanation. This vignette also provided the opportunity to assess the prospective teachers' subject-matter knowledge of this potentially difficult concept as well as examining their knowledge of students' conceptions. In the second vignette the subjects were asked to respond to the students' comments on a graph that suggests the misconception that functions must be linear, again providing an opportunity to assess the subjects' knowledge of functions. The third vignette presented an evaluation problem in which the student was asked to construct f(x+1) when they were given the equation for f(x). the fourth vignette presented a function obtained by composition and asked the subjects to respond to student comments about the nature of two functions f(x) and g(x) where h(x) = f[g(x)], and the fifth vignette presented confusion with respect to order of operations and how symbols are used to express operations with functions. Each response was analyzed and coded (with interrater agreement of .83) as mainly teacher-center (teacher discourse) or student-centered (students involved substantially in discourse) and what notion of mathematical authority was

used, i.e. does mathematics make sense in a real situation or is an explanation sufficient if it is validated by rules and procedures.

Results

Subject-Matter Knowledge

The analysis of the academic transcripts for the two groups of prospective teachers revealed expected differences between the two groups. The "undergrads" had an average undergraduate GPA of 3.0 while the Lab students had an average undergraduate GPA of 3.3. While the difference of three tenths might not be significant when one examines groups of students from two institutions, the 15-20 year difference in when these GPA's were earned is undoubtedly significant. All of the "undergrads" were mathematics majors while the Lab students' majors were from mathematics, engineering, physics, and computer science. In addition, seven of the Lab students have a Masters degree and three of these students have a Ph.D. in subjects such as computer science, mathematics, engineering, and physics. These students all have many years experience working in research; many have published a number of research papers and several have patents.

The analysis of Task I for both groups of prospective teachers indicated no differences between the groups with respect to the number of questions answered correctly. The following table indicates those results.

Written Assessment of Subject-Matter Knowledge: Task I

Group	Weak (0-10)	Intermediate (11-13)	Strong (14-15)
Undergrads	2	4	4
Lab students	2	4	4

In terms of which questions were answered incorrectly, differences in their subject-matter knowledge and experience with functions and graphs were revealed: each group exhibited certain strengths and weaknesses. The Lab students seemed to have the most difficulty with three questions. On one question the difficulties are reasonably attributed to a lack of familiarity with relations and functions displayed by arrow diagrams. Another question related to the graph of a piece-wise function and whether the function i. one-to-one, again a heavily symbolic notation. The third question asked the subjects to construct the graph of a composite function given two functions. Their difficulties on this question could be attributed to difficulties with function composition and/or interpretation of the graphical representation, a computer -generated graph with somewhat unusual notation.

The undergraduates seemed to experience the most difficulty with three different questions. One required examining five graphs and determining which represented a function. This result is significant since examining graphs and utilizing the Vertical Line Test as an instantiation of the definition of function is typically routine for even pre-calculus students. For 50% of the undergraduates to find this question challenging suggests that they were quite unfamiliar with functions when this task was administered. Two other questions were incorrectly answered by 40% of the undergraduates and illustrated inability to interpret the graphical representation of the function. These findings suggest that the undergraduates experienced many of the same difficulties utilizing the graphical representation to reason about functions as do typical pre-calculus students.

In terms of subject-matter knowledge, one possible hypothesis is that the Lab students may possess a deep and sustained conceptual understanding of mathematics in general, plausible because of the types and variety of majors, their advanced degrees, and the nature of the work in which they engage - scientific research and development. However, a lack of interaction with the specific vocabulary and notations in Task I could contribute to errors, but these errors would not reflect significant conceptual misconceptions. With respect to the undergraduates, one would expect them to possess greater familiarity with function representation and notation because their learning and tutoring experiences are fairly recent and contiguous in time. For this reason, their performance on Task I in general and certain specific items is particularly troubling. The responses on Task II will provide further evidence of the subject-matter knowledge of both groups and confirm or refute these findings.

Beliefs Scale: Task II

The beliefs of both groups were very similar as measured on the 32-item Beliefs Scale with internal consistency within groups of questions. Statistical analysis using the t-test of differences in means indicated that the two groups differed significantly at the .01 level on only one of the 32-items and these results are reported in more detail by Ebert & Risacher (1996). It was interesting to note that the Lab students were inclined to agree that "instruction can best remediate poor computational performance by the deliberate teaching of correct rules" whereas the undergraduates clearly disagreed with this statement. Given that the Beliefs Scale was administered during the Lab students initial experience in the program and that this statement reflects a long-held, pervasive view of "best practice", their agreement is not particularly surprising. The lack of agreement by the undergraduates can be attributed to their recent experiences in general education courses which undoubtedly emphasize conceptual understanding.

The results for both groups seem to represent a consistent belief system. The following table provides a list of strongly held beliefs in each of the categories.

Beliefs Scale Summary of Areas of Agreement

1. *Beliefs about the Learner*
   - Agree with the constructivist's view of student learning.
   - Agree with the role of the teacher as facilitator.
   - Strongly agree that "all students can learn mathematics" and that no "special" abilities are necessary.
2. *Beliefs about Learning Mathematics*
   - Strongly agree that "modeling mathematical ideas through the use of representations (concrete, visual, graphical, symbolic) is central to the teaching of mathematics."
   - Disagree that ideas should be explained in terms of formulas.
   - Strongly agree that learning should be embedded in authentic problem situations.
   - Strongly agree that learning should promote the development of both concepts and procedures.
3. *Beliefs about Mathematics*
   - Strongly agree that applications and modeling of data reflect mathematics.
   - Strongly agree that reasoning and logic represents mathematics.

Instructional Practices: Task III

Recall that Task III was coded as : teacher-centered, student-centered, and notion of mathematical authority. On the first vignette, 10 (five Lab students and five undergraduates) suggested responses where the teacher provided a correct explanation with an example that was related to the real-world context of the situation while the students were passive listeners. The most frequently occurring response (42%) is clearly teacher-directed with the teacher providing an explanation or sharing knowledge, the student receiving knowledge, and mathematical authority established through a review or establishment of formal definitions, symbolic representations, and algorithms or procedures. In some cases (23%), students are asked to explain their procedure or logic to the class for feedback. In an equal number of cases, the teacher utilizes either real-world contextual situations (10%) or perhaps numerical substitutions, technological tools, counter-examples or contradictions (9%) to establish mathematical authority while the students remain passive listeners. Approximately 16% of the responses could be classified as truly investigative in which the teacher orchestrates or suggests alternative pathways through a genuine invitation for students to engage in mathematical

inquiry or explain their reasoning to the class. These results are reported in more detail by Ebert & Risacher (1996).

In terms of between-group differences, the responses do not differ significantly. Both the undergraduates and the Lab students have approximately the same number of teacher-directed versus investigative responses. With respect to the quality of the responses, the undergraduates generated some very creative responses to genuine student dilemmas. For example, the undergrads were far more likely to suggest that students explore the mathematics and resolve the conflict through their own efforts. In several cases, this resolution utilized technology (TI-81 calculators) to provide an alternative source of mathematical authority. However, the undergraduates were also much more likely to exhibit misconceptions with respect to projectile motion and in diagnosing students' errors.
The responses of the Lab students on the vignettes were fairly traditional teacher-directed. In terms of the quality, the Lab students exhibited very few misconceptions on any of the tasks. In particular, the real-world tasks were very strong and extended more than any others to include other concepts and illustrate the connections with real world phenomena. Throughout the tasks, the Lab students consistently utilized accurate scientific information in their explanations.

Discussion and Conclusions

The analysis of the data for the two groups suggests that comparisons at different points in their respective programs is problematic. With respect to the assessment of subject-matter knowledge (Task I) and beliefs (Task II), the two groups were very similar and it was reasonable to administer the assessments when we did. The results imply that the traditional students in a four year university program preparing to be mathematics teachers have an impoverished understanding of functions and graphs in terms of concepts and notation, despite their recent course work which includes extensive attention to functions and graphs. By contrast the non-traditional students, experienced scientists, engineers or mathematicians, had difficulties with some functional notations and terminology but in Task III they exhibit few misconceptions about functions and they offer students accurate scientific explanations connected to real-world phenomena. Thus, it would seem that the non-traditional group has good subject matter preparation to teach functions and graphs, except for a needed review of notation and terminology. The remedy for the undergrads' understanding of functions and graphs is more problematic.

The profile of the beliefs suggests beliefs that would focus on all children constructing their own mathematical knowledge with teacher as facilitator. Thus it would appear that both groups express beliefs that are consistent with a reform view of mathematics and the learning and

teaching of mathematics; however, the results of the vignettes tasks indicate the majority in both groups describe teaching practices consistent with a transfer of knowledge by direct telling or the traditional view of teaching mathematics. For the Lab students with their limited experiences with current educational theories on constructivism, these findings are not unexpected. The fact that the Lab students expressed these beliefs at the beginning of their program is significant and bodes well for the development of their pedagogical content knowledge. We might speculate that increased familiarity with current reform theories would help the Lab students change their instructional methods; however, this is not supported by the findings for the undergrads in this study. For the undergraduates in their capstone course, their traditional view of teaching mathematics, although consistent with previous research, is problematic. It would seem that their courses in reform educational theories had not enabled them to operationalize these theories into classroom practices. One might hypothesize that both groups might have more facility with constructivist teaching practices as a result of the methods class.

One of the contributions of this study within the current research on teachers is that it carefully considered the complexities associated with pedagogical content knowledge for two important groups of prospective teachers. Rather than focusing on one aspect, this study considered several aspects of knowledge and beliefs and the relationship to specific instructional practices. This study also demonstrates the need to adapt teacher preparation programs according to the characteristics, strengths, and weakness of the participating students. This study also would encourage the development of teacher training programs in mathematics for non-traditional students from the ranks of experienced professionals such as those in this study. Their work experience and beliefs make them good candidates for teaching. While it is recognized that this study reports on analyses of data from only two small samples of traditional and non-traditional students, it provokes various considerations about how to assist various individuals in acquiring pedagogical content knowledge in mathematics. This study would also suggest collecting additional data on the actual classroom teaching practices of these two groups to analyze their development with respect to becoming effective classroom teachers.

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Second Career, Second Challenge: What Do Career Changes Say About the Work of Teaching?

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> The positive aspect of teaching is that it's always crazy, so it's real exciting. It's always a challenge, whereas my job was not always a challenge. (Kurt, a former computer systems analyst)

Over 20 years ago, Lortie, in the *Second Handbook of Research on Teaching* (1973: 490), called attention to the "odd gap" in our knowledge about teachers: "We have too few studies which explore the subjective world of teachers in terms of their conception of what is salient." He speculated that familiarity may have dulled our curiosity about the way teachers understand themselves and their occupational lives. In the past two decades some new ways of looking at teaching as work have emerged with a shift from trying to study the world of teaching as a public, social phenomenon to trying to understand how teachers define their own work (Feiman-Nemser and Floden 1986). As more second career people enter teaching and as progress is made in the restructuring of teaching as an occupation, advocates of change need to become more aware of how this more mature group of teachers see the work of teaching. Resulting reforms must take into account the need for a possible different mix of occupational satisfactions from those based on research conducted among a more traditional (first career) group of teachers.

Reports exist on the operational aspects of second-career teacher education programs (Adelman 1986, Carey, et al. 1988) but not on the actual participants nor on their reflections about teaching. These people are older and possess life experiences which are different from those of traditional credential candidates. What can these people tell us about the "work" of a teacher? What do these beginning teachers have to say about their expectations and their realities after being on the job? Are they happy with their career choice decisions? How do these second career people compare their present and former professions? What changes in their personal lives have transpired due to this change in occupation? What have they learned about themselves through this process?

In order to answer some of these questions about the meaning of work as found in teaching, I spent a year interviewing, observing classrooms, and analyzing the daily reflections of a group of 17 novice teachers. The participants in this study were new teachers of science and mathematics who were engaged in their first full year of teaching after a minimum of five years in business or industry. They had all completed a formal, graduate level, teacher preparation program which included a student teaching experience and were identified through their relationships with the teacher education programs at San Francisco State University, the University of Houston, and the University of New Orleans (Madfes and Schwartz, 1988).

Content versus Pedagogy

The classroom observations and the interviews indicated to me that all of these new teachers were proficient in their content areas of instruction. They knew the subject matter to be taught, but all cited a lack of skill in subject specific pedagogy. A new thought about teaching had been created through the experiences in the classroom--the difference between content and delivery. Karen, a former civil engineer, who is teaching math and computer science in Louisiana, was surprised to find that, "There's a big difference in knowing the material and teaching it. I don't think I totally understood the difference before and I definitely wasn't prepared for it." Other participants who had initially felt confident about their abilities to teach science and mathematics also found a difference existed between *content* and *pedagogy*. In Texas, Arnold told me:

> I never realized that teaching had developed into such a fine art. The better you are able to develop your teaching skills, the better teacher you are going to be. I would say that you have to go to school to be certified because teaching is very weakly related to your knowledge about physics. Teaching physics just doesn't have much to do with what you know about physics.

Similarly in California, Hans, who became a teacher of mathematics because he loved the subject, developed a new insight about middle school mathematics:

> Whereas I did find this kind of trivial math boring when I first started getting into it, I find out now that it is much more complex than what I had thought. Because the math is trivial, but the delivery is complex.

The participants' growing understanding of and appreciation for the differences in knowledge and practice were evidenced through comments in interview transcripts and self-reports. The previous applications of technical knowledge which they had experienced in

business and industry involved a matter of fulfilling a general norm (or project plan) as best they could given the materials and tools which they possessed. They were used to having a clear picture of what the end product was to be and were responsible for calculating the most efficient way of producing this product. This scheme contrasts greatly with the responsibilities of teaching, where simple applications of formulas and procedures are not workable in order to produce the desired end. In teaching, reflection upon various ways of achieving the ends becomes the focus and it is the knowledge that the means are prominent which becomes most important.

A theme that emerged through conversations was the real difference between knowledge, experience, and application. The participants were aware of the necessity of acquiring the hands-on experience of teaching in order to become more proficient in their new careers. They valued the student teaching process whereby they worked with a supervising teacher in order to gain both experience and confidence and said this period needed to be lengthened. The need for a practice period was further emphasized by the older participants who were conscious of the "instant expert" syndrome found in teaching. Several commented that, contrary to procedures in industry where no first-year engineer would be expected to carry the same load and deliver the same level of performance as a five- or 10-year veteran, new teachers were expected to do the same work and turn in the same level of performance as a 20-year veteran. These findings support those of other researchers in the field of teaching cultures who found that virtually all teachers in American schools assume full responsibility for student learning and for the independent management of a classroom from their first day on the job. Unlike the more gradual, incremental introduction that newcomers receive to other occupations, entry into teaching has been labeled "abrupt, unmediated, and unstaged" (Lortie 1975; Nemser 1983).

Reception by New Colleagues

Those who have encouraged the recruitment of industry personnel to fill teaching positions often do not give enough attention to the special needs of the people making the transition. Some have assumed that the transition would be an easier process for the already well-experienced worker than it is for the recent college graduate. In this study I found that the older, more experienced individual is in as much need of training and support as any other novice teacher. The person who has already been successful in one career and who starts a teaching career at mid-life feels as vulnerable and as inexperienced as a 22 year old who is beginning his first job. This person needs as much guidance and support during the induction year as any other novice if he is to be successful and is to stay in teaching. For as Kurt said, "Because, you know, in changing careers it's really frightening and it's really shaky. It destroys your ego."

In her work on "Teachers as Colleagues", Judith Warren Little states that "through work with others, teachers shape their perspectives on their daily work and revise or confirm their assessments of their career choices" (1987: 497). Habermas indicates, "No one can construct an identity independently of the identification that others make of him" (1979: 107). These notions were clearly exemplified by the older novice teachers who had a difficult time asking for help or sharing their insecurities with others. They were treated by their colleagues not as new teachers but as teachers new to the building. This mistaken labeling was not wholly due to the assumptions made by the experienced teachers. Ron admitted that he didn't know if his fellow teachers knew that this was his first year in the classroom. He also told me he was hesitant to let them know of his inexperience.

For the most part, the younger participants (ages 30-35) were more easily identified as newcomers. Veteran faculty tended to give these novices more support while the older participants were assumed to be experienced teachers; support was not offered unless it was requested. Arnold, one of the over-50 participants, told me "If I asked for help, I got it. The problem was that I usually didn't know that I needed help." While Arnold felt his colleagues were very supportive and would help to keep him on the right track, the reality must have been otherwise, for he violated several of the unofficial rules of the school and was asked to resign prior to the end of the year. The inability to ask for help, to reach out to others, or to socialize was revealed to be the most difficult for the oldest (ages 51-59) of the participants.

The successful movement from teacher education student, to student teacher, to full-fledged teacher is a period of transition that requires the incorporation of the individual into the new group and status. The novice may or may not be welcomed by new colleagues in the schools. There may be physical intermingling with members of the new group and the best attempts may be made to behave in teacher-like ways, but incorporation cannot be realized without acceptance. Even though the person performs the appropriate "social behavior performed for the sake of expressing a certain meaning or meanings of importance to the group concerned", (Eddy 1976: 438) there may still not be acceptance. The career changers were surprised to find that their acceptance by new colleagues was sometimes hampered by their prior careers. Fred said that his new colleagues were:

> ...somewhat threatened in the beginning because they thought that 'an engineer is, wow! This guy is an engineer and he's coming to teach.' But I'm sure I'm not a threat to anybody. I'm trying to learn from them. Their experiences are a lot more useful than my engineering experiences for teaching. I keep expressing that I need help from them.

Jane did not think that her teaching colleagues had a high opinion of their own jobs for they thought that she was "foolish" for thinking she could make a difference. She reported:

> They find it hard to believe that someone who could work at something else would actually choose to teach. This has been said to me more than once. On my first day someone said, "You mean you're a chemist, you mean you could actually do something else? If I could do something else I'd get out of here so fast."

The only exception to this off-putting attitude was experienced by Steve whose old career as an animal researcher actually helped in his acceptance as a faculty member. He said:

> It's been nice coming from another career because I wasn't just another teacher coming in. People said 'you've worked with animals?' You save one person a little animal problem, such as 'Oh, what kind of medication should I use?' It's been helpful to get to know these people, all the people, like the office people, help their animals out. That worked out kind of nice.

An interesting interpretation of relationships with co-workers was made by Dave who described why these relationships were now different:

> In my prior work settings, other than in my own company where I was the boss, they were different in the sense that there is no competition now. And there was before. So you don't form the same kind of relationship with someone who's trying for the next step up that you would with someone who is a peer.

Thus as the new teachers began to think of their colleagues as peers and not competitors, new patterns of behavior were needed in the workplace. As these new behaviors were being learned the participants also began to reach out for more help.

The Work of Teaching

As interpreted by the participants, the cultures of the schools in the three states were more similar than dissimilar. Thus the assimilation of the participants did not vary according to geographical differences but reflected an assimilation to a more general culture of teaching.

The participants all used qualifiers such as *more* or *less* to describe what they found in teaching. These terms were in relation to comparisons with previous work settings. They found teaching to be *more* demanding than anything they had ever done and also *more*

rewarding. They described teaching as *a play* and as *a game* with changing players and circumstances. They spoke in terms of the constantly changing atmosphere and challenge of the classroom which provided a situation that was never boring.

When comparing the work of teaching to that of their previous careers, many found that teaching was much more demanding because, as commented on by Arnold, "You are constantly probing and shaping the behavior of the students; your emotions and your behaviors are very important." Or as expressed by Dave, "It's a much higher responsibility because you're not supervised the same way that you are in a traditional workplace. It puts more personal pressure on you to be really on focus and on task and to be getting through the curriculum." The nature of the responsibility was also illustrated by Neil's comparison, "Instead of being responsible for a great deal of money, I'm now responsible for 125 children."

The search for a way to contribute to the greater society and to mean something to somebody had led many of the second career people to teaching. In the classroom they found a way to meet their own needs as well as the needs of others. Once they began to teach they experienced stress, joy, frustration, and enjoyment. The job of teaching was hard but the work of teaching provided personal satisfaction.

> Well, before I had to go (to work) to get some money. So it was sometimes agony going to work. Now it's just not work hardly. You know, I almost feel like I'd pay them to go down there. (Jack)

In comparing the job of teaching to the jobs they had previously held, all participants mentioned the adjustments required due to the absence of feedback on their performance as compared to the feedback that was provided at previous jobs, the isolation from adults, the stress, the lack of formal support mechanisms and structures, and the exciting and frightening autonomy of the classroom. The autonomy of the classroom was found to be both a positive and negative feature for the new teachers. Some expected more bureaucracy and control over their actions and were pleasantly surprised to find that they had total choice about what they could do in the classroom--they had the opportunity to make daily decisions about their own actions. Janice found that, [Although I have] "a lot of control over what I do as a teacher, I have less control over where I have to be and when I have to be there."

The isolation of the classroom was a key complaint about teaching and was continuously described by the participants throughout the year. The daily logs cited numerous entries, such as this one by Karen, responding to the probe: "What did you dislike most today?"

> Today was like many others. Sometimes things get so hectic and I have so much paperwork that I can go all day without speaking to another adult. I didn't say more to any of the other teachers than 'hi' as I saw them in the hall.

The complaint about lack of feedback and loneliness also seemed to reflect a feeling of being neglected by those in charge.

> I don't know if it's new teachers or everybody in general, but the school's so big that it's almost like you're not there. I mean I'm a brand new teacher, never taught before, and nobody's ever come to observe me. It's almost the end of the first semester and nobody's ever been in my classroom except for you. No other teacher's ever come by and asked me if I need anything. I mean, I guess they look at my lesson plans, but they have no idea what I'm doing in my classroom. (interview with Karen)

In interviews and daily logs the participants cried out for recognition and affirmation. They repeatedly spoke of their hunger for adult conversation, but conversations concerning their classroom activities. The isolation they reported was of a professional nature and could be cured by feedback from others as to how well they were doing as teachers.

Age Factors: The Older Participant

The participants in this study actually represented two different subgroups: one group had completed a full career and had retired prior to entering teaching and the other was composed of true mid-life career change individuals who had come to teaching with a different set of expectations and needs. In interpreting the text of this study I found many differences associated with age between the oldest second career people and the others, differences which crossed geographic boundaries and prior work experiences. Most of the participants stated they were happier in teaching and felt more fulfillment through their work now than they had in previous work settings. The exceptions were the three oldest participants who did not return to a second year of teaching. Fred, a 57-year old former engineer, commented in one of his logs that, "Teaching is very rewarding but very taxing. Maybe too much for someone my age." This became a theme when speaking with the older second-career people. Although all participants had previous work histories, the oldest (55-59 years) of the participants emphasized their age and previous work more often than did others. Fred described his classroom experiences as being hectic. He said, "It was very energy consuming. It took a lot of effort on my part and was probably the toughest job I ever had to do. Maybe a younger man would have found it a little easier." Because the oldest of the participants found teaching to be

strenuous as well as stimulating, they often wondered about reduced teaching loads which would accommodate their desire to contribute as well as their desire to not have to work full-time. As these people were receiving some type of retirement income, the reduced salaries associated with partial teaching programs was not a factor to be considered as a negative.

Conclusion

Although the focus of this study was on a small group of second career teachers, and this article only relates a small portion of what I found, the reader is urged to generalize the discussion to a larger and more encompassing group of novice teachers. The participants in this study were verbal, articulate, and mature workers who were able to quickly assess their new workplaces and responsibilities and share their reflections as to how the new surroundings and activities affected their lives. Younger beginning teachers who do not possess the same maturity and wealth of work experiences often are unable to articulate their frustrations and joys after such a short time on the job due to having to learn to "work" as they learn to "teach". It is no wonder that after five years, one third to one-half of new teachers leave the classroom. The voices of the participants in this study represent the voices of a much larger group of novices and should be listened to in order that conditions can be improved so that those who wish to teach, love to teach, and are able to teach effectively will arrive and stay in this nation's classrooms.

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Part 2

A Case Study

Part 2

A Case Study

Introduction to the Case Study

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The credential program for mathematics and science designed for Lawrence Livermore National Laboratory (LLNL) employees has been a unique experience for many of the people involved. This program has been the fulfillment of ambitions and dreams for many of the students as well as for the planners. To date, this project has included approximately 60 credential students and four LLNL support persons. Twenty faculty from San Jose State University have participated directly in the project, and numerous additional faculty and staff have participated indirectly. The credential program has existed over a four year period with various individuals involved at different points in time. The individuals and/or groups of people involved are distinct with respect to background, motivation, and goals associated with their involvement in the program. Therefore, it seems appropriate that the description of this project includes comments and reflections from individuals from each of the major groups. Each will tell about a unique and personal experience with the LLNL/SJSU Mathematics and Science Credential Program. The "voices" which speak about the program include the organizers from the Lawrence Livermore National Laboratory and from the Science, Mathematics, and Education faculties from SJSU. We also will hear from the credential students who studied in the program and from public school cooperating teachers who worked with the credential students. An external perspective will be offered by an educational researcher from WestEd/Far West Laboratory for Educational Research who analyzes the factors for success by discussing a similar second-career program. Yet another perspective is given by a mathematician from the University of Delaware who compares the knowledge of mathematics and pedagogy of traditional students to the career scientists and mathematicians of the LLNL program.

A Specialized Teacher Preparation Program in Mathematics and Science: Overview of Rationale and Concerns

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Rationale and Background for the Program

Providing sufficient numbers of qualified science and mathematics teachers has been a serious concern in the United States for more than a decade (Bullock, 1993; Urrows, 1986; Bell, 1983). It appears that economic and societal issues often negatively influence the decision of many mathematics and science students to consider teaching (Carey, 1988). For example, the salary and prestige of teaching is relatively low when compared to other career choices in mathematics and science. It is ironic that the increasing technological nature of our society requires more science and mathematics teachers to train tomorrow's work force, and at the same time creates intense competition that lures scientists and mathematicians into industry and away from teaching.

Attracting career individuals to teaching may be a real possibility at this time. The number of individuals seeking career changes has been increasing over the past 10 years (Lacey, 1988; Herr & Cramer, 1988) and Bliss (1990) notes that a common motivation for career change is for individuals to return to an earlier desire to become an educator. Such opportunities may be increased at this particular time in history due to the current downsizing of the scientific military government complex. Many national laboratories with excellent scientists, engineers and mathematicians are experiencing internal reorganization, which could result in job insecurity and dissatisfaction causing newly hired staff to be fearful of their low seniority and older employees to look toward second career/retirement interests. A number of previous attempts to retrain experienced professionals for teaching suggest that the "traditional" program of teacher training is not necessarily appropriate or effective with the non-traditional student (Training Second Career Teachers in Math/Science Education, 1990; Madfes, 1991); consequently, attention to the design of a new program would seek to address the specific needs of experienced professionals and their job situations.

Partners in the Teacher Credential Program

The idea to offer a part-time teaching credential program in mathematics and science originated with the Lawrence Livermore National Laboratory (LLNL, or the Lab). The Lab is primarily a research laboratory operated under the direction of the Department of Energy (DOE) and is located in northern California, close to the San Francisco Bay area. The LLNL Human Resources Department offers a variety of educational opportunities for the laboratory employees. Due to a directive from the DOE for the Lab to become involved in the improvement of science education, the Lab sought a university to cooperate with them in offering a teacher credential program for science and mathematics to the employees. Many employees initially expressed an interest in such a program.

As a result of inquiries to local universities by LLNL, a partnership was formed with San Jose State University (SJSU) to offer a part-time teacher training program designed especially for the Lab employees. The LLNL/SJSU Teacher Credential program was begun in science in the spring of 1993 and in mathematics in the fall of 1993. The program is in its third year of operation. San Jose State University (SJSU) is a large comprehensive university of about 30,000 students located about 40 miles from LLNL. SJSU is noted for its computer science and business majors which join the highly technical work force of the Silicon Valley. The teacher credential program produces most of the teachers for the area. The surrounding population has multiple ethnicities and many public schools have a majority of "minority" students.

Specialized Features of the SJSU/LLNL Program

A challenge for the university was to appraise the work situation and the unique qualities of the experienced scientists, engineers, and mathematicians at Lawrence Livermore Laboratory and design a teacher preparation program that would be attractive and feasible for them to pursue. For example, it was unrealistic to expect these professionals to quit their high-paying jobs to engage in the full-time, one-year, on-campus program; however, many might consider a part-time program whereby they could consider teaching while still employed. Similarly, the maturity level of these students and their years of experience in the field of science and/or mathematics would call for some changes in the curriculum as compared to the on-campus program, designed for younger and recent college graduates.

Time Factors and Duration of the Program

The teacher training programs of educational institutions are designed primarily for the full-time college student pursuing a first-time career. Because the students in this program continue

to be full-time scientists and engineers at LLNL and are generally persons with significant other commitments to family and community, the teacher training program needed to be redesigned accordingly. It needed to be a part-time program that put acceptable demands on the student's time and yet made the goal of earning a teaching certificate obtainable within a reasonable period of time. Participation in the program is a demanding "overtime" situation for the students and would be deemed acceptable for only a limited number of years.

The LLNL/SJSU credential program has been spread out over two years instead of the one year which is normally required in the on-campus program. The on-campus program is a fifth year graduate program for persons who are already competent in their subject area. This program assumes students are not working and can devote their full attention to the program. To finish the LLNL/SJSU program in two years, students would be taking 5-7 credit hours each semester. The LLNL students also have the option of extending the program another semester or two by delaying some of the student teaching requirements until the course-work has been completed.

Location

The program addresses the time factor by holding the classes at the LLNL facility. This saves the students considerable driving time as the campus is about 35 miles from LLNL. Likewise, every effort is made to have the students observe classrooms and do their student teaching in schools close to their home or work. The university professors do the driving instead of the LLNL employees. This arrangement seems greatly appreciated by the students but has presented a hardship for the faculty, most of whom are already pressed for time.

Pace and Content of Courses

It was anticipated that some areas of the regular university courses are taught at a pace and level not appropriate for this group. From looking at the educational background and professional experiences of this highly sophisticated group it was concluded that some "regular" course material could be condensed or taught at an accelerated pace in the LLNL program. For example, topics concerned with statistical methods of measurement and inferences included in the Evaluation course are normally taught assuming no background in statistics. However, the LLNL students are quite knowledgeable and experienced in statistics and need at most some discussion of statistical applications to educational issues. This difference in the teaching of statistics accounts for considerable difference in time required on this topic. In like manner, other topics can be covered at an accelerated pace due to the sophistication, experience, and dedication of the Lab students. The compacting of material in

the courses resulted in several courses in the on-campus program fusing into two courses. It was also anticipated from the research literature and from comments from the Lab Human Resources personnel that the Lab students would be immediately interested in science and mathematics and in methods of teaching them. Therefore, it was decided to offer these courses at the beginning of the program and delay the education foundation courses until the second year.

Increased Time with Students in Classrooms

A concern is that the conventional two semester credential program is too intense and too short for candidates to gain sufficient appreciation of students, schools, and teaching approaches. This concern seemed even more acute for career professionals whose contact with public schools and today's youth may be extremely scant. The extended time of the program offered time to expose these career professionals to today's schools and students over a minimum of four semesters.

Program of Studies for the SJSU/LLNL Program

More descriptive detail about the design and rationale of the SJSU/LLNL credential program, its courses, and requirements will be offered by the authors from science, mathematics, and education, each from his/her particular perspective. Also these authors will make various comparisons of the SJSU/LLNL program with the on-campus program concerning the actual courses and student and faculty satisfaction. For the reader's reference, included in the Appendix is an actual list of the courses for the SJSU/LLNL program and the regular on-campus program.

Areas of Concern to Be Addressed in this Work

Each of the three partners of this new program had a number of concerns at the outset of the program and throughout the program. Various data, both qualitative and quantitative, have been organized to describe the concerns of the partners, illustrate the areas of success in the program, highlight the problematic areas of the program, and suggest implications for similar future programs. The authors of the following chapters will collectively address the concerns associated with this program. They are summarized as follows:

Concerns of the University

1. Will a teacher training program designed especially for experienced persons in the fields of mathematics and science increase the number of qualified science and mathematics teachers at this point in time?
2. How would such a "tailor-made" program for existing professionals differ from our on-campus program, assuming full compliance with the state requirements?
3. What evidence of effectiveness, advantages, or disadvantages would result from this new program as compared to the standard on-campus program?
4. What difficulties will be encountered in organizing and managing such a program?
5. What direction does the experience with this project provide for future projects of this type?

Concerns of the Laboratory

1. To what extent will professionals be interested in such a program?
2. To what extent will interested persons complete the program?
3. How much support would the Lab (employer) be giving?
4. How will participation in the program affect the participant's regular job performance?
5. What implications will the experience with this project provide for future programs for Lab employees?

Concerns of the Students

1. Will this program meet my expectations?
2. What difficulties will I encounter during the program?
3. How will I use this teaching credential?
4. What have I learned from this experience?
5. How will participation in this program be viewed by my management?

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An Idea is Born for National Laboratory Employees to Become Teachers: View from the Research Laboratory

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The Teaching Credential Program at Lawrence Livermore National Laboratory (LLNL) was begun in response to the Department of Energy's (DOE) directive that the national laboratories get involved in science education. The Laboratory is rich in highly educated scientists, many of whom are in interested in teaching at a secondary school level. These scientists recognize the need for highly knowledgeable people to teach at a pre-university level. This population provided a source of potential teachers. Knowing that this situation existed, Laboratory personnel conducted a survey to determine how many people would be interested in a teaching credential program. The Lab's professional population at that time was approximately 4,000 people. The response to the first survey was over 800 people who expressed a desire to teach.

Finding an Innovative Credential Program Partner

Armed with this data, the Lab began a search to find a university willing to design a teaching credential program for individuals who would be working full-time. The program would have to allow for evening courses, part-time practice teaching, and be flexible enough to accommodate professionals who worked more than a 40-hour week and frequently traveled as part of their assignments. When given the requirements, school representatives refused to consider such a non-standard course of study. Of particular concern was the practice teaching component.

The search for a university came to a successful conclusion when Dr. Dan Walker was located at California State University at San Jose. Dr. Walker is a professor in the School of Science, Department of Science Education. He listened to the Lab's requirements and designed a program to satisfy those requirements without compromising the high standards demanded by San Jose State University or the California Board of Teaching Credentials. His first task was to get the program approved by San Jose State University then to petition the state for approval.

Forming the First Class of Students

While the search for a program was being investigated, a second survey was mailed to the Lab population. It questioned Lab personnel about the seriousness of their desire to teach in hopes of getting a much smaller population. The response to the second survey was about 500 people who felt they would be willing to participate in a teaching credential program if offered at the Laboratory. From these surveys it was decided first to concentrate on those who wanted to teach physical science at a secondary level.

Having found an innovative program at San Jose State University, the Laboratory proceeded to collect a group of pioneers to enter the first class. An application packet was designed to meet the needs of San Jose State University and the Laboratory. People from Survey #2 who met at least the basic qualification were invited to apply for admittance to the program. The first application packet was strong enough that very few changes have been made.

The new program was marketed in the Lab's in-house newspaper, *NEWSLINE*. Noontime informational meetings were held to explain the program to potential applicants. The meetings featured Dr. Walker explaining the course of study with Dorothy Freeman of Academic Programs available to answer Laboratory-related questions. Application packets were made available to interested Lab personnel. This resulted in 26-28 people requesting interviews.

Dr. Walker had been concerned about the communication skills of the Lab scientists and engineers. This proved not to be a problem. The interviews went well and 24 people were admitted to the first class. The composition of the class was 13 Ph.D.'s, five with master's degrees and six with BA/BS level degrees.

Success Factors for the LLNL/SJSU Credential Program

Upper management at the Laboratory fully supported the program. The Student Policy Committee gave the project a vote of confidence. Tuition expenses were covered from the educational account. Classroom space was made available. Managers permitted class members to adjust work schedules in order to participate in practice teaching. Human Resources contributed people to staff the project. The Teaching Credential Program received and continues to receive favorable publicity at the Laboratory.

Why did this program work at the Laboratory? The raw material was available in the form of professionally educated scientists with a desire to teach. The Laboratory management has always been pro-education and has been supported in this position by the DOE. Tuition was

paid by the Laboratory, flex time was allowed by managers, and students willingly gave their time and energy. There was a person at the Laboratory who believed in the project, was willing to work to get it going, and was strongly supported by her management.

The university contact, Dr. Dan Walker, had imagination and was willing to be innovative and creative. He designed the program specifically to meet the needs of highly educated adults who worked 40+ hours a week. The program was run through the College of Science rather than the College of Education. This made the program more valid to professionally trained scientists. The key to its credibility was having a Ph.D. science professor from San Jose State University hold the information meetings, interview the potential students, and teach the first two courses. We were able to get some early buy-in from local school systems.

Research Scientists and Mathematicians Prepare for Teaching: What are These People Really Like?

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The Lawrence Livermore/San Jose State teacher preparation program was designed for the experienced professional research scientist and mathematician. With this emphasis on creating a program especially for a particular and unusual group, it is suggested that some detailed and personal sketches of a couple of the graduating students will help the reader understand the nature of the program and its significance.

The two-year credential program provided the opportunity for close relationships to develop between each student and the university mathematics or science director of the program. This relationship began with individual interviews with the director and his/her counseling of the student about the program. The directors were involved with teaching the first courses of the program, with seminars throughout the program which discussed the field experiences, and with supervision of many of the student teachers. Each director remained the advisor for the student during the entire program and helped him/her with the process of applying for the state credential. A highlight of the personal qualities and accomplishments of each student given by the directors at a graduating banquet illustrated the exceptional qualities of the Lab students, their potential contributions to education, and the close relationships that had developed. The graduates were clearly a group of highly motivated and competent mathematicians and scientists who were now equipped and eager to contribute to the education of future mathematicians and scientists as teachers.

This section gives a personal sketch of two of the graduating students. The goal is to give the reader a more personal glimpse into members of this group as was done at the graduating banquet. The students will illustrate the uniqueness of the participants of this program and their potential contributions as teachers. The purpose of this section is to help the reader appreciate this group of students and the value of a program that enables them to become teachers. Likewise, these sketches should show the need for a uniquely designed program for these individuals. (General observations are from the program directors and university supervisors. Facts and quotations are from the students' application materials, from cooperating teachers, and from the students and their spouses (names are pseudonyms).

Lee Cornwald

Lee Cornwald is a tall, slim and distinguished 57-year- old who has worked in industry for 30 years. He smiles a lot, laughs easily, and is noted for his enthusiasm and perpetual optimism. His wife of many years tells stories of him on a number of backpacking trips with his family and as a volunteer leader with the Sierra Club's outing program for inner city teenagers. It seems that upon reaching the destination, Lee often charged into the lake or river with such gusto that he had minor injuries on more than one occasion. He speaks of some of the inner city teens in the Sierra Club program as "tough kids ...(who) brought along their guns and dope," but also says "some kids were easy to relate to while others were frustratingly distant, but overall it was a good experience." Lee had several very demanding cooperating teachers, primarily because he sought out teachers with the best reputations for teaching mathematics. These teachers were far more critical and exacting than any others in the mathematics program; however, Lee remained enthusiastic and kept his positive attitude during many potentially discouraging situations and critiques. When teaching mathematics, Lee often laughed loudly or used positive interjections (Wow!) that were quickly mimicked by the students in an unkind way; however, he was not offended, but maintained his enthusiasm with the class.

Despite his easygoing manner, Lee is persistent, scholarly, and diligent in his responsibilities to a fault. He is a highly accomplished physicist with B.S., M.S., and Ph.D. degrees in physics. He also studied electrical engineering and optical science for several years each at two universities. During all of his academic work, Lee maintained GPA's in the 3.4-4.0 range. He has some 13 publications and patents to his credit and has had scientific and managerial responsibilities in many different areas. A letter of reference describes one of his accomplishments as "he has managed the operation of the AVIS laser system as well as accomplished a multitude of specific optical engineering tasks on the same laser system ... one should understand that this laser system is the highest average power visible laser system in the world today." Lee was also the first of the credential students to take the National Teachers Exam in mathematics, an exam that is noted for foiling even recent mathematics majors with excellent records. He took the exam even before the mathematics refresher course in the program had been completed and was "anxious just to try the exam." He passed with flying colors and requested to give a presentation to the rest of the class to help them prepare for the exam. Lee was always prepared and generally over-prepared for teaching his mathematics classes. He would often create his own materials that integrated interesting science applications with mathematics and he would search for fun mathematics puzzles to liven up his classes.

The teaching program requires that the student teachers attempt various innovative teaching techniques, which Lee always planned and executed whole-heartedly and well.

Lee is constantly concerned for others which seems to be the source of his desire to be a teacher. Lee writes of himself, "Teaching and learning are enjoyable to me, as are talking and interacting with young people. I am analytic-minded and find satisfaction in teaching others to solve problems." His concern for others is illustrated by his volunteer work with inner city teens as described above and also by his sponsoring college students in summer work programs. A work colleague comments, "He interacted closely and effectively with a number of graduate students being very helpful. kind, and sympathetic and popular with them." Another colleague writes, "He is more than willing to help others solve technical problems or other work-related issues... which makes him a very valuable co-worker." This concern for others was evident throughout his practice teaching. Lee's height makes him stoop when talking to most people and especially to his mathematics students, effecting body language which visually conveys his attitude toward others: that of always wanting to meet people where they are and to help them. In his introductory letter for the program he notes, "I am pleased to have three grown children who all finished college," and a reference letter states, "Knowing how much time and devotion he has given his children, I know he is a natural teacher."

Stephanie Marcos

Stephanie is a pleasant woman who always has a ready smile and a friendly word for her colleagues. She has a small build and is fairly short with dark hair and characterizes herself as having excellent interpersonal, oral and written communication skills, which she demonstrated was clearly the case over the course of the program. One of her supervisors of several years said, "She possesses poise and grace and a strong work ethic, and a high level of mental discipline." Another reference said that she is "focused and persistent in solving problems. She is not afraid to ask for help or guidance when necessary." Stephanie gives the impression of being very quick intellectually and also has a quick wit; however, she was also fast to comment when elements of the program did not go smoothly or homework assignments were not clear.

Stephanie joined the program about a month late, which put a tremendous demand on her to make up an overwhelming amount of work. I cautioned her about the unlikely possibility of her being able to succeed in this first course at this late date. One of the biggest criticisms students made of the program was the rigorous demands of the first course, a review course to assure students had extensive knowledge in mathematics and to help them pass the national teachers exam in mathematics. This three credit course reviewed practically all of

undergraduate mathematics! However, Stephanie did make up the missed work and obtained one of the highest grades in the class.

Stephanie has been a computer scientist at the Lab for almost 20 years. She specializes in solving engineering and physics problems using a variety of computer environments and languages such as FORTRAN, C, UNIX, MacOS and UNICOS. She has an M.S. in Business Administration/Operations Research from a California state university. Stephanie was born and raised in Greece where she attended a high school for girls only. She remarks that she was lucky to have an excellent math teacher who inspired her as well as taught her a great deal about mathematics. In Greece she had to pass a national exam to enter the university. She passed with flying colors on her first attempt and was accepted to study mathematics, her number one choice. The course of study in mathematics at The Aristotelian University of Thessaloniki was a very demanding one, including the study of several mathematics courses each semester. She graduated with the rating of "very good" on her studies. She earned a 3.5 grade point average in her master's program at the California state university.

Soon after Stephanie graduated from college she married and moved with her husband to California. In her first two years in the United States she proceeded to get her master's degree, start working for the Lab and have two children! Considering this history, I should never have worried that entering the credential program a month late would pose a problem for Stephanie. She has worked continuously at the Lab except for taking off one year to "spend more time with the kids and get more involved with their schools." Stephanie has been very active in the PTA and as a classroom volunteer in her children's schools. She has also taken leadership roles in Expanding Your Horizons, an organization to bring girls ages 6-12 in touch with women in science and math and thereby encourage them to study mathematics and science. Stephanie says that she always helped her own children with their math studies and always had the idea of becoming a mathematics teacher in the back of her mind.

Stephanie's first teaching assignment was in a middle school. With her excellent mathematics skills and intellectual bent, I was not certain how she would fare with these younger students. It was obvious in the seminar group of all the students doing student teaching that she was having the most fun and success with her students. Stephanie raised the level of mathematics content and expectations of the students far above that normally expected in this grade, and she was concerned about possible objections from the parents and students. However, the parents were delighted with her teaching and the students begged her to stay. She was able to introduce student-centered activities along the lines of investigations and made mathematics like playing a game for these young students. She had her students working hard and thinking critically and logically about mathematics and enjoying it!

When Stephanie was offered a second student teaching placement in an accelerated senior high school class, she took it on in her usual ambitious manner. Again, I cautioned her about the amount of work required for a novice teacher to teach such a class. She found that the best and brightest high school mathematics students are a very critical group. She also found that they expect perfection from their teachers. Even with an excellent mathematics background, Stephanie found that she had to actually do most of the mathematics homework assigned to the class each night in order to be as quick as the students in answering questions the following day. In addition, each night she had to prepare the new lesson for the next day. She had several particularly troublesome students and was having a great deal of difficulty in maintaining an attitude of authority in the class. She became very discouraged and actually considered dropping the class. Keep in mind that she was also working a full-time job as a computer scientist at the Lab. I was very concerned that her own standard of excellence would become a stumbling block for her at this time. However, she did not drop the class, but she had to take several vacation days from work in order to keep up with the demands of teaching this class. I kidded her about being the student teacher with the most overhead transparencies per lesson as she was extremely well prepared for each lesson. Stephanie also adopted a different approach with her students in that she expressed an attitude to her class that she was "just a novice teacher" and that she would be reviewing and relearning this mathematics along with them. She needed their help to set up more of a partnership for learning between them and she could and would make mistakes just as they would. She did establish a better working rapport with this class, but probably had one of the most trying experiences of all of the student teachers that semester. Stephanie concluded this experience by expressing a great deal of respect for the task of teaching the accelerated math students at the high school level. She was very proud to earn her teaching credential at the end of that semester and invited her cooperating teachers to the banquet honoring the credential "graduates".

A Teaching Credential Program for Research Scientists: The View from Science

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Origins of the Program

The motivations to pursue a science teaching credential program at Lawrence Livermore National Laboratory (LLNL) were several. Our region of California, like most of the state, had a shortage of science teachers and a severe shortage of really good science teachers. We believe that the poor performance in science by American students is related to poor science teaching. The chance to attract first-class scientists into science teaching at the secondary level was an opportunity far too good to pass up. Plus, even if not every graduate of the program made it into classroom teaching, the knowledge and experience gained by these people would surely make them into educational activists, school board members, liaisons between LLNL and local schools, etc. Combining the prestige of an LLNL scientist with the knowledge of education they would gain could only yield positive outcomes. We also were interested in cooperating with LLNL in our role as a comprehensive university.

We recognized at the outset that scientists at LLNL were a very different group of people from the students we attract to our on-campus credential program. Most of the scientists were older than the usual credential candidate, they possessed an extremely high level of scientific expertise in a specialty field, and many of them served in leadership positions at LLNL. Few had any dire t experience with schools except as seen through the eyes of their children and the newspaper. Because all of the applicants would continue working full-time in demanding jobs at the Lab, we could not expect them to devote as much time and effort to a credential program as traditional students do: we had to stretch a program over a much longer period of time.

Early in the planning stages for developing this Program, Professor Walker, the SJSU Program Coordinator, gave luncheon presentations at LLNL to discuss teaching careers with potential applicants. As expected, the audience was particularly interested in teaching job availability (which is excellent in science locally), how much course-work was required, salaries for entering teachers, etc. Those who remained interested in obtaining a credential were provided with applications and interviews were arranged at LLNL.

Initially we at the university were somewhat concerned that this population of scientists would include some excessively introverted people that would not function well in a classroom of today's youngsters. Thus, our interviews were structured to assess personality more than subject matter background. The discussions centered on issues such as why do you want to teach children, what recent experiences have you had with youngsters, did you like school and if so why, etc. Our intention was to accept only those with people-oriented personality skills who also had a strong content background in science or engineering. To our pleasant surprise, virtually every applicant interviewed was personable, articulate, concerned about education, and at least somewhat familiar with young people (such as the friends of their children). In hindsight it is evident that LLNL selects its employees rigorously, taking account of both content expertise and interpersonal skills. When setting up similar programs at different sites, it will pay to review the hiring criteria and interview procedures used by the employer. Some institutions may have already done much screening for their employees which can assist in selecting potential applicants to a credential program.

The Curriculum: Evening Content Courses

Given the talent and experiences of such a group, we were concerned that courses taught in our on-campus program would not be well received. The pace of some of our courses would probably bore and frustrate some of the fast learners. We fully expected that course content that was not immediately relevant to a classroom situation would not be well received since this is the usual orientation of adult learners. Thus, too strong a dose of educational theory or philosophy in the absence of obvious applications to the classroom might lead to early attrition from the program. Thus, in the initial courses in the program, we chose to emphasize applied-learning theory, and in a way that minimized generic educational theory by focusing only on how to teach and learn science. The one course in our sequence that was devoted to conventional educational theories was placed last in the sequence. Our thinking was that the educational theory component would be better received after the students gained more background, and we expected little attrition this late in the program.

The Science Education Program at San Jose State University has very close ties to a network of local science teachers. These teachers advise the faculty at the university and act as the Resident Supervisors for our science student teachers during their teaching practicum. These teachers and we science education faculty have discussed teacher preparation at length over the last several years. Our consensus is that conventional (i.e., two semester) credential programs are too intense and too short for candidates to gain a good appreciation of students, schools, and teaching approaches. It must be appreciated at this point that in California, teacher certification is a fifth year (meaning graduate level) program by state law. Thus, most teacher

candidates preparing for the secondary level have not been in any kind of "future teacher curriculum" as undergraduates. Thus, candidates must bear the expense of an extra year of study (i.e., 30 semester units) to obtain course work that leads to certification. To hold down the financial burden, many students cram this study into two consecutive semesters only, and the resulting intensity impedes learning and insight into teaching and learning.

We wanted to take this opportunity to create a credential program that avoided the weaknesses of our on-campus program which, by the way, are similar to those in virtually all California universities as well as many nationwide. We designed a program that lasted longer, had more student teaching, and had less university course work. By eliminating certain courses and consolidating others, we created only three education courses compared to the five that exist in our on-campus program. We more than doubled the amount of time to be spent in functioning school classrooms, both as a teacher's assistant and as a student teacher.

We were also concerned, however, about the knowledge base in science of our aspirants, especially the older ones. This credential was to be in Physical Sciences, which carries the certification to teach any of the physical sciences such as physics, chemistry, geology, astronomy, etc. Given how specialized a scientist can become in a research setting such as LLNL, we reasoned that some of our people may not have had contact with some very important concepts in physical science for many years. How many people, including Ph.D.'s, can possess a strong and current background in physics and also ones in chemistry and geosciences? Few, if any, in our opinion. We saw the need to upgrade the science knowledge base that would be needed to teach in today's science classrooms.

A second important concern of ours was to transition the thinking of our scientists away from how they were taught years ago and towards the modern, conceptual and learner-centered approaches that characterize the current reform movement in science education (National Research Council, 1990, 1994; American Association for the Advancement of Science, 1989, 1990, 1993). Rather than have our students expect to lecture extensively with the use of overhead transparencies (a familiar form of communication at LLNL), we wanted to set the tone up front in the program that science instruction should focus on only relevant and interesting concepts learned through discovery and other laboratory-intensive lessons. Years of experience have demonstrated to us that breaking the "teach-how-you-were-taught" syndrome is no easy task. We worried that *if* older learners are more set in their learning/teaching habits, we needed to model extensively the newer educational approaches and expectations.

We, thus, added an additional course to the program on *Concepts in Science*, which became the first course in the sequence. This course is not part of our on-campus program although it probably should be. Most of this course consists of the students teaching each other in small groups. Every week, each student was assigned a particular important concept in the

physical sciences that must be taught to the group next week. Most of this course consisted of the students teaching each other in small groups. The first few weeks of the semester also included some instruction in teaching and learning to provide teaching models and standards of performance.

The concepts were chosen by the instructor from the State of California *Science Framework*, the official document that is to guide science teaching at the K-12 grade levels statewide (California Department of Education, 1990). Other educational expectations included that, whenever possible, the lesson was to be student-centered and laboratory-based. Finally, no scientific terminology was to be used in the teacher's explanation of a concept; that is, the students were required to practice speaking in non-technical language. Following each presentation, the members of the learning group met privately to critique the teaching using a critique form developed by the course instructor, Professor Walker. The student teacher was then invited back to meet with the group and discuss the critique. The course instructor also added input in the cases where he had observed the presentation. Assessment was based on how well the students performed in their teaching roles, as monitored by a combination of the group's and instructor's critiques. Improvement in performance over the semester was an important grading criterion.

Thus, the LLNL Science Teaching Credential Program became four content courses, plus required experiences in secondary science classrooms, which were offered sequentially over four consecutive semesters. Each content course met for one three-hour evening meeting per week. Classroom observation and student teaching were scheduled to meet the needs of each student. LLNL management was cooperative in allowing the scientists flex time in order to spend time in the schools while also continuing their full-time job commitments. Course instructors were as flexible as possible to allow some of the scientists to miss class time due to job-related travel. Class sessions were videotaped in most cases so that an absent student could view what happened in class.

The second semester course of the sequence was *Methods of Teaching Secondary School Science*. This course is the most important one in any teacher preparation program because it covers the practical aspects of how to teach the particular subject and operate a successful classroom. Although the university faculty in science education at SJSU have also taught at the secondary level in their careers, we believe strongly in using a current practitioner to help teach this methods course. Thus, this course was team taught by Professor Walker and Jerry Stuefloten, an outstanding high school science teacher. Both instructors were present at all class meetings and closely integrated their instruction. We believe that the combination of a practicing teacher plus a doctoral level scientist/science educator provided powerful credibility in the eyes of the LLNL scientists. Most teacher preparation programs and many classroom

practices in K-12 science are not well-respected by knowledgeable professionals such as practicing scientists. Winning the respect of the students is always necessary before it's possible to change preconceived notions such as what deserves to be taught and how it should best be taught.

As one measure of the acceptance of the course instructors and their approaches, we occasionally had the roomfull of LLNL scientists (students) sitting in circles on the floor playing fun games used to socialize youngsters into a positive classroom setting. Initially, several in the group felt quite uncomfortable doing "adolescent level" activities, but they soon developed trust for us and realized that these activities were an important part of their education to be successful teachers.

Assessment in the methods class was strictly performance-based. Each student was required to produce a portfolio of products developed throughout the course. These products included a selection of lesson plans developed by them to demonstrate various teaching styles and approaches, classroom management plans, a statement of personal philosophy towards teaching, and other relevant documents. The course instructors critiqued and reacted to these products initially and allowed the students to revise their work until they, the students, were satisfied with the products. Course grades were based on the active participation of students in class plus this portfolio. These portfolios also serve the purpose of representing the student teacher's work in support of applications for teaching jobs when the participants finish the credential program.

The third content course was *Evaluation and Classroom Management*. As the title implies, the course was a combination of evaluation methods and aspects related to issues in classroom management, especially legal responsibilities of the school and teacher. The fourth and last course in the sequence was the *Foundations of Secondary Education*, a course focused on the historical, philosophical and psychological backgrounds of American education. These last two courses were taught by College of Education faculty and are discussed in another section of this monograph.

The Curriculum: Student Teaching

During each of the four semesters in the program, the students were to be in schools and classrooms. During the first semester, the objective was to observe teachers and students and wherever possible, to be an assistant to the teacher in charge. This experience was to allow the candidate to get a feel for the science classroom. We expected that a few students might elect to discontinue the program once they learned what schools and classrooms were all about. As expected, a few of the initial 23 students discontinued at the end of the semester. Most, however, remained committed to obtaining the credential. In a semester- end reflection paper

on their experiences, they demonstrated keen insight into the problems and the joys of science teaching. Some of these papers were so insightful that we plan to publish them as a group at a later time to provide an assessment on schools and schooling from career scientists' perspectives.

During the second semester, the classroom experience included spot teaching, tutoring students, grading papers, setting up laboratory activities, and observing. Each participant taught at least 20 days over the semester, and many were allowed to teach more. An unfortunate although predictable problem arose in several cases: Some of the Master Teachers insisted on teaching approaches contrary to those that we were advocating in the program. Put another way, these classroom teachers were (and probably still are) teaching in an older, teacher-centered style that emphasized factual details over conceptual understanding. Any divergence from those attitudes and teaching styles was not welcome. The students in these situations shared their frustrations and impressions during class discussions. Common observations were that this older mode of teaching did not motivate the students and that it must contribute to why science is not liked by many younger students. The positive side of this situation was that our scientists/students in the program were able to see what not to do in a science classroom.

Most teacher preparation programs face this problem from time to time, and it helps explain why new teachers entering the profession are not always well received for their new ideas and approaches. A crucial element of success for a teacher preparation program dedicated to reform is to identify appropriate, supportive Master Teachers to work with the program. A student teacher must receive consistent philosophical support in order to try and to succeed in new approaches. A critical and negative Master Teacher can easily undo the best of instruction by university personnel. Because we at San Jose State had not worked previously in the area around Livermore, we did not know the local teachers or schools. Thus, our students initially took "potluck" in a student teaching assignment. However, a tribute to the knowledge and maturity of our LLNL scientists is that they both survived and intellectually grew from some of these more negative experiences.

Semesters three and four consisted of intensive student teaching. Each semester the candidates taught a science class by themselves for the entire semester. One semester the teaching was in a middle school setting while during the other semester the teaching was in a high school setting. Not surprisingly, the workload of teaching plus a full-time job was regarded as heavy and the stress often intense. A few of the students continued to suffer under poor Master Teachers. Some Master Teachers handed the grade book to the student teacher on day one and virtually disappeared for the semester. On a couple of occasions, the Master Teacher assigned our student to their most unruly and uncontrollable class and then offered

little support and advice. Is this just bad judgment or some form of vindication against the system? We will not be using these Master Teachers in the future.

Not all of our students elected to student teach during semesters three and four, although everyone continued in the evening content classes. Many of the people delayed the intense student teaching semesters until a future time when job responsibilities were not so great. It's too early to predict how many of these who have delayed will eventually finish the student teaching and complete the teaching credential. Likewise, it is too early to predict how many of our graduates will eventually become classroom teachers.

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A Credential Program for Research Laboratory Employees: The View from Mathematics

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Background and Rationale

In the past decade there has been a major effort by mathematics educators to improve the teaching and learning of mathematics. Ideas about the nature of mathematics as well as how to best teach mathematics have undergone a change. The traditional view is that mathematics is a body of knowledge or set of rules and facts to be transmitted by the teacher to passive students through memorization and drill. The reform movement adopts a constructivist view that the learner must actively engage in building personal knowledge through relevant thought-provoking activities and reflection. Mathematics is the first discipline to adopt national standards which illustrate this philosophy with respect to the notion of what is mathematics (NCTM, 1989). In addition, the way in which mathematics is taught is equally important for teaching a reform curriculum and NCTM has also set forth national standards on the teaching of mathematics (NCTM, 1991). Major efforts have been ongoing to improve the mathematics curriculum and teaching along the lines of the reform standards. A major problem with the reform ideas being adopted quickly is that traditional beliefs on the nature of mathematics and teaching are inconsistent with those of the reform movement (Cooney, 1987). The past president of the National Council of Teachers of Mathematics, Jack Price, recently posed the question, "Will we bring thousands of people to join us in building a better mathematics education for all students, or are we talking to each other while waiting for the change that never comes?" (Price, 1995). He concludes with the advice to persevere, in that change does not happen quickly. In addition to reform teaching being contrary to tradition, it calls for a deep understanding of mathematics and how it is used to solve real problems such as those encountered in physics or biology. Most mathematics teachers have little experience in solving real-life problems; rather, they possess a theoretical or textbook knowledge of mathematics. Investigative inquiry into situations involving mathematics is not a strength of many current mathematics teachers.

One of the primary motivations to offer this program was the shortage of qualified mathematics teachers for middle and secondary schools. Many current high school teachers in mathematics classrooms do not have the established credentials or expertise normally required to teach mathematics (Bullock, 1993; Curtis, 1993). The scramble of school districts to fill mathematics teaching positions from a scanty pool of candidates has resulted in many states hiring temporary teachers without a mathematics teaching certificate or comparable mathematics training. Unfortunately, these "temporary" or "emergency" appointments exhibit a pattern of perpetual renewal. In California the situation in mathematics is worse than any other subject in terms of sheer numbers of temporary certificates to teach mathematics. The State Education Department in Sacramento reports no years in which it did not issue mathematics emergency teaching certificates. The 1991-1992 data reveals 611 new emergency teaching permits with at least part of the assignment in mathematics with 25 teaching math and physical science. In that year there were also 701 reissued or renewed mathematics emergency teaching permits. Schools must show that they have made a serious search but could not find a credentialed teacher before they are issued emergency teaching permits (personal correspondence from Mike Mikibbon, 1993.)

Many permanent middle school mathematics teachers do not have a full credential to teach mathematics or have only a small fraction of the background required for a full credential. As a result of mathematics teacher shortages, common practices and policies have resulted which allow elementary teachers with a multiple subject credential to teach mathematics in grades 7, 8, and 9, grades that have traditionally required a mathematics teaching certificate. In most cases these teachers have minimal mathematics background and/or interest. This situation was recently illustrated by the math department chair who reported to a California Academic Partnership Program steering committee that her school, a large middle school in south San Jose, has less than 50% of the mathematics teachers with certificates to teach mathematics or even interested in teaching math. Rather, the teachers have simply been assigned to teach math due to need.

As we allow teachers with such a meager background to teach mathematics to the impressionable youth of the middle grades, it is a serious concern that this instruction may dissuade even more students from pursuing careers in mathematics. In California, an elementary teacher with as few as 13 college credit hours in mathematics may obtain a supplemental credential to teach mathematics courses through Algebra I. By contrast, the California mathematics teaching credential typically requires 52 hours of college mathematics and an additional 12 hours of science, a "Methods for Teaching Mathematics" course, and at least 180 hours of practice teaching of mathematics in a secondary school supervised by an experienced mathematics teacher and a university mathematics education specialist. Note that

the supplemental certificate requires no practice teaching in mathematics nor a methods course. It is also not uncommon for teachers with a supplemental certificate to ease into teaching higher mathematics courses as well.

Origin of the Program

The basic question is how can we increase the number of qualified mathematics teachers to teach the citizens of tomorrow who will compete in a world with increasing emphasis on technological expertise. Additionally, how can we increase the number of mathematics teachers who have a deep understanding of mathematics concepts and can apply mathematics to real problems? Current strategies to attempt to solve this problem take many forms ranging from a "peace corps" strategy of temporary teachers as in the Teach for America program, to monetary incentives to lure students into teaching through free tuition in exchange for a number of years of teaching. Another approach has been to seek disillusioned persons in other fields such as business, and retrain them to become mathematics teachers. A major drawback to this approach is the amount of time required for students to study sufficient mathematics as the person may have studied only a minimal amount of mathematics in college many years prior. All of these strategies have shown limited success and are only a partial solution to the problem (Maxwell, 1994).

In response to the situation described above, the mathematics education faculty saw the chance to recruit some prominent mathematicians, engineers, and scientists from Lawrence Livermore National Laboratory (LLNL or the Lab) to teaching as a wonderful opportunity. In the winter of 1993, Dan Walker of the Biology department approached the Mathematics Teacher Education Committee with the idea of offering a credential program in mathematics at the LLNL similar to the science program which was in its second semester. The only concern of the committee was related to the personnel necessary to operate such a program. Most of the faculty were heavily committed to ongoing projects in the local schools or involved with heavy campus responsibilities. Under the leadership of a new faculty member, Billie Risacher, the Teacher Education Committee made several trips to the Lab to discuss the program with the human resources personnel, view the teaching facility, give presentations about the Mathematics Credential requirements, and interview prospective students. Fortunately, much of the groundwork had already been accomplished by the science program: a working partnership had been established between the Lab and the University and an innovative program plan in terms of philosophy and sequence of courses had been planned. In addition, Dan Walker acted as a support person to assist in getting the mathematics program organized.

The Mathematics Credential Program differs from the regular campus program at SJSU in that it entails increased contact with students and schools over longer periods of time, courses

are offered at the Lab in the evenings over a two year period, and the program begins with courses in mathematics and methods for teaching mathematics rather than with education courses. With only slight course modifications, the mathematics program follows the design of the science program, which is described in more detail elsewhere in the science program description. The mathematics program approval processes on campus and at the state level also followed in the footsteps of the science program and therefore met little resistance.

Subject Matter Competence of the LLNL Students

To obtain a teaching credential in mathematics in California one must demonstrate subject matter competency. This is done either by passing several sections in mathematics on the National Teachers Exam (NTE or PRAXIS exam) or by completing courses which cover an established list of mathematics topics, generally comparable to a mathematics major. Although most of the LLNL students were working directly with some form of applied mathematics, the majority were not mathematics majors in college and were missing several courses from the established list of courses to satisfy the competency requirement. The variety of college majors is illustrated below:

Student	Bachelor's Degree	Master's Degree	Ph.D.
1	Computer Science		
2	Math/Comp Science	Computer Science	
3	Electrical Engineering	Electrical Engineering	
4	Physics	Physics	Physics
5	M.I. Science	Nuc. Eng. (course work only)	
6	Physics	Physics	Physics
7	Mathematics	MBA - MIS and MS in CS	
8	Math	Math	Math
9	Computer Science		
10	Computer Science	Computer Science	Computer Science
11	Computer Science		
12	EE & CS	MBA	
13	Math		
14	Math	Computer Science	
15	Math		
16	Physics	Material Science	

From their transcripts, it was determined that most of the students needed to take the Mathematics NTE or PRAXIS exam. The exam requirements for California consist of three parts and is designed to cover the same areas as those studied by a mathematics major. It is noted to be quite difficult and has a high rate of failure, even among math majors. The scores needed for passing in California are the highest of any state in the country and California requires three exams to be mastered while many states require only one or two. The first exam consists of 120 multiple-choice questions to be completed in two hours. This exam covers a range of topics from advanced high school math through the senior year of college math and requires very quick recall of facts and procedures. The second and third exams are called "Proofs and Models" and each has only a few problems to be fully explored in a discussion or proof format for another one hour each. These sections are supposed to test the student's ability to solve problems by developing logical arguments and to illustrate a thorough analysis of the problems including considering alternate hypotheses. Furthermore, the presentation should be well organized and clearly stated and illustrate expertise in the subject.

It was decided that additional instruction in mathematics would greatly aid the LLNL students in passing the national exam. It would also put a wide range of math concepts at their fingertips. An extensive review of mathematics would prepare the LLNL students to confidently teach any mathematics course from middle school to even the most challenging of high school math classes. Given the variety of majors and current work assignments of the students, it was anticipated that most would need a thorough review of at least some area of mathematics. Thus the program began with the first required course being an upper division mathematics course, Math 201A. The course was especially designed for the program and consisted of a concise but thorough review of the required courses for the credential program. A team of faculty from San Jose State University were selected for his or her individual expertise in an area of mathematics. Each faculty member taught a subject of mathematics for approximately two 3-hour sessions; for example, calculus was taught in six hours of class time. The goal was for this intense review to refresh the concepts of each course and provide a base for continued independent study by some students. In some cases where students had not previously taken a course, Math 201A served to alert them to areas in which they needed additional tutoring or study.

Reflections on Unique Aspects of the Mathematics Program

During the first two semesters the Lab students were spending one hour a day in local schools observing and eventually acting as classroom aids. Each week for one hour, Dr. Risacher met with them to lead the group in discussing their experiences. This seminar seemed to be an important time to reflect on the students and curriculum of today's schools. It also

acted as a student support group and a troubleshooting mechanism for the initial semesters of the program. For example, some students had teachers that were reluctant to let them help in the classroom and other students would share how they had solved similar problems.

A listening and flexible attitude by the program director and the SJSU faculty was necessary as the students were adjusting to tremendous pressures on their time. For example, a number of students had routine travel as part of their LLNL responsibilities; therefore, video tapes of classes were made available to the students and assignment deadlines were frequently made flexible. All the SJSU faculty were made aware of these factors and were cooperative.

The faculty consensus was that the Lab students were extremely conscientious and did not take advantage of the relaxed time-line policy of the program. In fact, the opposite was sometimes the case in that students with legitimate reasons to turn in late work would work heavily on weekends or take vacation time to accomplish the assignment rather than exercise the relaxed late policy. In a similar vein, an assignment to write a short position paper would result in writing an extensive research paper by many of the LLNL students.

After the first two semesters, the course load of the two-year program plan increased from five credit hours to seven credit hours, which included student teaching a class each day in the local schools and continuing to take a three credit course one evening a week and participate in the student teaching seminar. Only five of the mathematics credential students took the full seven units as described in the program plan during the third and fourth semesters. The others delayed the student teaching until after the course work had been completed. It would seem that the course load originally outlined by the program was too demanding for most of the mathematics credential students. There were few complaints about other aspects of the program, and no mid-stream corrections needed to be made.

Unfortunately, the initial "crash course" in mathematics put tremendous pressure on the students. While they complained greatly about the workload, the experience seemed to create a bond among the students and many began meeting on their own time to work together on the homework assignments and tutor each other. None of the students dropped out of the program due to this first course, and all were successful in it. A more unfortunate result of this first course was that it illustrated a type of teaching which was exactly opposite of the goals of the current reform movement in mathematics education as described in the *Standards for Curriculum and Instruction* (NCTM, 1989). The *Standards* espouse the philosophy of using student observations, hypotheses, and investigations to help students develop mathematical ideas. The role of the teacher is not to be a dispenser of knowledge, i.e. facts and theorems; rather, the teacher is to act as a facilitator to help the students reason and form their own concepts and ideas about mathematics. This model would call for class time being spent with students doing much of the communication rather than listening to a lecture. Unfortunately,

Math 201A was a lecture course taught at a super intense speed. However, the teachers were receptive to reform methods in teaching as discussed the following semester in the methods course, and exhibited reform teaching in their classroom teaching.

The high level of professional and practical experience has been noted to be of benefit to the cooperative teachers and to the schools where the LLNL students do their student teaching. The cooperating teachers frequently remark on the exceptional computer capabilities of the student teachers in generating supplementary materials and tests which are far superior to what is common in their school. The cooperating teachers express appreciation for this enhancement to their curriculum and frequently use these materials in their other classes. In other instances, the LLNL student teachers have designed classroom experiments which produce data illustrating key concepts within the curriculum. Even some of the most expert and experienced teachers have complimented the LLNL students on these novel and meaningful ways of approaching concepts in mathematics.

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An Innovative Path to Teaching: The View from Education

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Chronic shortages of qualified science and mathematics teachers have been the norm in the United States for more than a decade (Urrows,1986; Bullock, 1993). Shortages are partly due to restricted numbers of college students entering these fields, possibly a result of inadequate instruction available in high schools. In part, shortages result from the intense competition for talented students of science and mathematics in both private and public sectors that has made careers in teaching comparatively unattractive (Carey, Mittman, & Darling-Hammond, 1988). Shortages of science and mathematics teachers, coupled with the large number of well-educated scientists, mathematicians, and engineers employed in industry and public service (defense and energy research, for example) have led some to argue that programs be made available to provide for an easy transition into teaching for those interested in a mid or late career change (Carey et al., 1988). Recent cutbacks in defense spending have increased chances for attracting such individuals into teaching careers.

While there is considerable appeal to this proposition, it is not automatically given that experienced mathematicians, scientists, and engineers will find satisfaction in teaching careers or, for that matter, that those who are attracted to teaching will find success in the classroom. Madfes (1991), for example, discovered that scientists and engineers from Chevron's Encore Program did not always fit comfortably into the culture of schools and, in many cases, were not welcomed by their new colleagues with the same levels of support accorded new teachers entering the profession in a more conventional fashion.

Despite the popular notion that success in teaching is primarily a function of subject matter expertise and prior academic performance, there are many other factors that contribute to success. Factors credited for success in teaching include dispositions and beliefs about teaching and learners, the ability to motivate students, manage a classroom and, of course, create and carry out instructional activities that help a broad range of students to understand, appreciate, and acquire the kinds of knowledge, skills, and dispositions entailed in a curriculum. The Teach for America program, for example, was founded on the belief that service-minded graduates of the best universities could quickly and easily be prepared to successfully step into inner city classrooms. Many reviews of this program have found it to be

a disaster both for the young college graduates who participated and the children they were eventually hired to teach (Darling-Hammond, 1994).

The induction of practicing mathematicians, scientists, and engineers into teaching careers has considerable common sense appeal. The idea also raises some important questions about who these prospective teachers are, what special needs and talents they bring to the profession, and how best to educate and induct them into teaching. As the need for qualified science and mathematics teachers grows and cutbacks in federal funding for research increase, there are likely to be more programs designed to help professionals in science and mathematics related fields obtain teaching credentials.

This paper reports on a joint project between the Single Subject Credential Program at San Jose State University and the Lawrence Livermore National Laboratory (LLNL) in Livermore, California. The project is designed to prepare self-selected mathematicians, scientists, and engineers from the Laboratory to become credentialed science and mathematics teachers in California. Over the past two years, the program has attracted over 40 students, 10 of whom were credentialed last year. Our first two years working with such a group of students from Lawrence Livermore Laboratory has given us some insights that have helped us rethink various aspects of our program. This paper will report on several aspects of the program from the point of view of faculty in teacher education who have worked with the program. Based on my own observations and communications to me by my colleagues, I will comment on students' backgrounds and qualifications for teaching, factors that may limit or strengthen their potential for success in the classroom, and the problem of designing a program that meets both the practical and substantive needs of these students.

The LLNL Students' Unique Characteristics

Academic Preparation

Students in the LLNL program come to us with extraordinary subject matter backgrounds compared with the majority of students in the on-campus program. Students admitted to the program thus far represent what we consider to be among the best and brightest from the pool of mathematicians, scientists, and engineers who might eventually be attracted to teaching from the public and private sectors. Most of these students hold undergraduate and graduate degrees from top universities, and some have Ph.D. degrees. Although most of the LLNL students are working directly with some form of applied mathematics, science, or engineering, many have academic backgrounds that do not fully qualify them to teach in their chosen content area. To obtain a teaching credential in mathematics in California, one must demonstrate "subject matter competency". This is accomplished either by passing the SSAT/PRAXIS exam (formerly

known as the National Teachers' Examination) in the appropriate subject or by completing courses which cover an established list of topics, generally comparable to being the subject area major. The majority of these students did not have sufficient course work to exempt them from taking the exam. While most of them were working in concentrated areas of specialization, they had been away from the study of their discipline for a considerable period of time. This latter fact has contributed to some frustrations, particularly for those required to take SSAT/PRAXIS to establish subject matter competence in California.

Professional Experience

Most of the LLNL students have more than ten years of experience at the Laboratory and have assumed leadership roles on major projects. Most have also experienced a number of specialized job-related training programs. All of the LLNL students have extensive experience in the application of their specialized knowledge to a variety of interesting problems. For example, the resume of many LLNL students list patents to their credit. This depth of knowledge and experience has, in the opinion of many faculty teaching in the program, accounted for an unusually high degree of creativity in the development of lessons and units that motivate student interest and understanding.

Beliefs of the Students

One of the most powerful influences on teachers is their general beliefs about education and the educational system - what schools should aim to accomplish, for whom, under what conditions, and for what reasons. It has often been the case that students bring such beliefs into the program, and that these beliefs can be quite resistant to change. While credential candidates are not always able to articulate or provide a rationale for their belief systems, they nonetheless profoundly influence the ways in which they ultimately practice their craft. A central concern for teacher education programs is to help candidates make their tacit beliefs explicit and examine them in the light of both the reality of public school teaching and the philosophical literature on education. One particular orientation reported by faculty (and confirmed by many of our students) is a strong belief in the overriding importance of merit in terms of effort and ability. This belief appears to many of our faculty to be more deeply felt by the Lawrence Livermore cohort than is the case for most students in our regular campus program and, perhaps, due to their extensive experience in a working environment that prizes merit and self-initiative, more resistant to change. This has important consequences for the way these prospective teachers view motivation, achievement, grading, classroom management, and instructional practices. An example of this philosophy is illustrated by one student teacher's

"slogans" which he relates to students in a casual and one-on-one manner. One of these slogans is "Ever notice how you get lucky on tests when you've been working hard?" It would seem that many of these credential candidates are extremely hard working and dedicated and desire to instill these qualities in their students.

At the same time, the expectation that students will (or should) be self-motivated and that evaluations of students' performance should solely reflect merit can have dysfunctional consequences for prospective teachers. One of these consequences is a high level of frustration when confronted with classes (particularly introductory level classes) that include a preponderance of students who do not exhibit a high degree of self-motivation, who have experienced a high failure rate, and who often resist the best efforts of teachers to encourage them to turn these patterns around. Many of the candidates in the program have expressed a sense of helplessness and frustration in trying to cope with this kind of situation. Efforts to help these candidates develop instructional, motivational, and evaluation strategies to better serve such populations of students have needed to confront directly an implicit conflict in values. Several faculty in the program have reported extensive discussion and debate surrounding just these kinds of value questions. Candidates, it should be noted, are receptive to such discussions, but are quick to challenge assumptions that run counter to their beliefs.

Equally important to beliefs about education and the educational system are the beliefs a teacher has about his/her field of study. For example, the majority of LLNL mathematics credential candidates express a view of mathematics as a way to solve very real and practical problems, and they can readily give numerous examples of such. These are traits many of us would like to see more of in students in our on-campus program. Such beliefs about the nature of mathematics or science, coupled with a wealth of practical experience, show evidence in this program of translating into powerful and creative approaches to instruction. According to several supervisors in the program, an interesting corollary is that some of these student teachers struggle in working with texts that stress rote memorization of procedures and formulas. While this condition causes some problem in student teaching, it reflects a perspective on teaching the education faculty welcome and encourage. Indeed we believe that these candidates are well positioned to challenge and overcome dysfunctional instructional materials and methods. Unlike many of our regular campus candidates they seem unlikely to "regress to the norm" when they begin working with experienced colleagues who advocate outdated approaches to teaching their subject.

Design of a Credential Program for the LLNL Students

The LLNL program was designed to accommodate the special needs and talents of the population of students it serves. Previous attempts to prepare experienced professionals for

teaching have not proven appropriate for the non-traditional student (Training Second Career Teachers in Math/Science Education, 1990). Consequently, attention to the design of a new program should seek to address the specific needs of experienced professionals and their job situation.

Time Factors and Duration of the Program

Most teacher preparation programs are designed for the full-time college student pursuing a first-time career. The on-campus Single Subject Credential Program at San Jose State, like all California teacher preparation programs, is a fifth year graduate program for persons who are already competent in their subject area. This program consists of a subject-specific methods course, psychological and social foundations courses, courses in reading and evaluation, and two student teaching experiences consisting of 12 semester units. Full-time students are able to complete the on-campus program in two semesters.

Students in the Lawrence Livermore program continue to work full-time as scientists and engineers; consequently, the teacher preparation program needed to be redesigned accordingly. First, courses needed to be offered in the evenings or on weekends as much as possible to allow continued full-time employment. Observing in the schools and student teaching occur during the normal working hours; consequently, these were stretched out over the two years so as to lessen the overlap with the Lab's working hours. The Lab has been very cooperative in arranging flexible schedules to accommodate students engaged in practice teaching.

The LLNL program is designed to be completed over two years, during which time students take 5-7 credit hours each semester with the option of extending the program another semester or two by delaying some of the student teaching requirements. Thus far, our experience is that only about one third of the students elect to finish the program in four semesters. The majority of students delay the student teaching, thus requiring at least two extra semesters. This results in a total of three years to complete the program. Students report that participation in the program is a demanding "overtime" situation for them and is acceptable only to the extent that they can "see the light at the end of the tunnel."

Location of Program

The SJSU/LLNL program is conducted at the Livermore site for the convenience of the Lab employees, another way of trying to accommodate these busy professionals with full-time employment. Another factor of the off-campus location coupled with the "part-time" nature of

the student teaching experience is that university faculty observe the students less frequently than the on-campus students - generally every other week as compared to every week. The student teaching experience over a longer period of time is seen as an advantage for the student; however, less frequent observations are definitely a disadvantage, especially if a student teacher is experiencing difficulties.

Curriculum Modifications

In addition to time and place adjustments, certain modifications were made in the program content. Changes were made for both practical and pedagogical reasons. From a practical perspective, we wanted a program that would be sufficiently compressed to allow students to finish in a reasonable amount of time. Pedagogically we wanted a program designed to focus on what we perceived to be the special needs of this population of students. A one unit classroom management course was added, as were early field experience courses. The decision to add these courses was based on early indications that concerns about being able to relate to and manage a classroom of adolescents would be a paramount concern for this group of prospective teachers. As much as these are issues for all new teachers, they are matters of grave concern for older candidates who are accustomed to working in an environment where their authority is rarely questioned.

Other courses in the program were consolidated and, in some cases, repackaged to adjust for the time frame of the program and the maturity level of the students. For example, Foundations of Secondary Education became a condensed version (three units rather than six) combining the two courses in social and psychological foundations that students on campus normally take. On the one hand, this combination reduced the time required to complete the program, an important practical concern. On the other hand, it reduced the opportunities to consider foundational issues related to teaching and learning, a matter of some concern for these students as well as for faculty.

A course was added at the beginning of the program to review "concepts" in mathematics or science to refresh and supplement students' content knowledge. In part, this course served as a refresher for those who needed to pass the SSAT/PRAXIS. In addition, this course attempted to model desirable pedagogy by approaching mathematics or science in a more investigative and "student centered" manner than the LLNL students had probably experienced in schools. There was some concern that the students' conception of teaching might be the typical lecture and overhead format so common in the scientific community.

It was anticipated that some areas of the regular university courses might be taught at a pace and level not appropriate for the LLNL students. From looking at the educational background and professional experiences of this highly sophisticated group, it was concluded that some

"regular" course material could be condensed or taught at an accelerated pace in the LLNL program. For example, topics concerned with statistical methods of measurement and inferences which are included in the on-campus Evaluation course are normally taught assuming no background in statistics. However, the LLNL students are quite knowledgeable and experienced in statistics and need at most some discussion of statistical applications to educational issues. This difference in the teaching of assessment and evaluation accounts for considerable difference in time required on these topics. In like manner, other topics can be covered at an accelerated pace due to the sophistication, experience, and dedication of the Lab students.

Faculty who teach in this program have reported a much higher than average degree of intellectual engagement. Despite their demanding work schedules, Lab students typically come to class prepared to discuss and often challenge readings. Moreover, they tend to show a greater than average degree of interest in the theoretical and empirical underpinnings of educational ideas and practices. This results in deeper, more meaningful and, in some cases, more extensive treatment of topics. Students were quick to criticize assignments, readings, or attitudes from professors that did not recognize their level of sophistication and maturity or that conflicted with their own ideas and beliefs. Consequently, faculty needed to revise their courses and instructional methods accordingly. Most faculty in the program welcomed the students' willingness to challenge ideas and force them to rethink some of their own methods and materials.

Extended and Increased Contact with Students and Schools

Probably the most significant difference in the LLNL credential program is the extended contact with students and schools. During each of the four semesters in the program (or four of six for students who extend the program), candidates were to be in schools and classrooms. The objective for the first semester was to observe teachers and students, and where possible, assist the teacher. This experience was intended to allow the candidate to get a feel for today's classrooms. We expected that a few students might elect to discontinue the program once they learned what schools and classrooms were all about. Fewer than 10% of the initial students enrolled in the program discontinued at the end of the semester, a percent comparable to the attrition rate of the on-campus program. In a reflective paper on their experiences at the end of the first semester, the LLNL students demonstrated keen insight into the problems and joys of teaching. It was clear that for most, the decision to pursue the credential program was grounded in a well thought out commitment. While the program was designed to accommodate the special needs of these students, it still demanded a considerable amount of time and energy. Few appeared to have taken this commitment lightly.

During the second semester the students were to assist in a classroom and teach several short units which fit into the curriculum plan of the Cooperating Teacher. Some of the students experienced out-dated curriculum and methods of teaching modeled by their Cooperating Teachers, but most had been given the freedom to try new approaches and were able to make good progress in their classrooms. What we did not see with this cohort was any inclination to defend outmoded practices as practical necessities - something we observe with some of our on-campus students. During the last two semesters, the student teacher assumed full responsibility for a course in a middle school and in a high school. For those who have completed the program, this extended exposure to schools seems to have been beneficial. On-campus students experience a much shorter induction period. The Livermore students in contrast continued to take classes for several semesters while working within schools and thus had more varied and structured opportunities to reflect on their experiences.

Conclusion

Given the special circumstances surrounding this program, the adaptations that were made worked remarkably well. A high proportion of those who entered the program have stuck with it, leading us to believe that adjustments in structure, timing, and duration were well suited to student needs. The students themselves have been a revelation to many faculty. The knowledge, skills, commitment, and maturity that most exhibited has led us to believe that programs of this kind can indeed provide public schools with teachers who have outstanding potential. Whether the qualities of these students are representative of the population of potential teachers that might be drawn from other careers is debatable. The Lawrence Livermore National Laboratory is a research facility that draws from among the best and brightest potential teachers drawn from other occupations might not exhibit the same depth of knowledge or kinds of experience in applying their disciplines. Moreover, they may not exhibit the same degree of intellectual curiosity.

In reflecting on the curriculum, two points seem worth noting. First, certain topics can effectively be treated in an accelerated and advanced manner. Instructional methods and testing and evaluation courses are two examples. On the other hand, certain foundational issues, particularly those related to equity, diversity, and special needs populations may require more extensive and extended treatment. It was noted earlier that many of our students enter the program with belief systems that may limit their willingness and ability to reach out to students who will need their help the most. From what we have seen, such beliefs have been shaped by a decade or more of working in an environment that has little tolerance for those who lack ability or motivation. What I think we see in this case is less a lack of sensitivity and concern than it is a conflict between the cultures of the institutions they are trying to bridge. The

curriculum, therefore needs to be adapted to help students to better grasp the significance of these cultural differences and to explore their own value systems conscientiously throughout the course of the program.

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A Program to Become A Teacher: Views from the Students

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Interviews with the majority of the students in the LLNL/SJSU science teaching credential programs concerning how expectations were or were not met by the program were conducted. The consensus was that the program as a whole was well planned and executed.

Courses

Students felt that the course work was valuable; in particular, the courses in science content, methods of teaching science, evaluation, and mainstreaming were immediately applicable to the classroom. The materials on directed inquiry, cooperative groups, mainstreaming, and evaluation pitfalls and methods were particularly useful. Most students would have liked more time with these instructors to benefit from their knowledge of the practical aspects of teaching, perhaps with an emphasis on exercises that teach some of the skills that can only be learned by doing.

Opinions about the utility of the Foundations of Education course was mixed. Some felt that the material presented was thought-provoking (and useful for that reason) and pertinent to classroom experience. Others felt that the material was removed from what was being experienced in the classroom and was therefore not so useful. Some felt that the course requirements did not take into account the workloads of the students. Others commented that the level of instruction was aimed at undergraduates and was not appropriate for the intelligence level of the students.

Preparation for Teaching

Consensus was that the actual teaching was perhaps the most useful and instructive part of the entire program. Only teaching truly prepared the students to teach. The course work was applicable and mentally primed student teachers to look and prepare for certain things, but only by teaching did they learn to teach. The weekly lessons taught in the first semester were particularly useful and provided practice in articulating concepts before students were required to do this with children. It was recommended by one student that more teaching could have

been incorporated into the observation semester, though other students were thankful for the extended period of observation.

The extended period over which the student teaching was done was perceived to be an advantage of this program. Making habits of, and incorporating into a repertoire, ideas learned in a classroom setting takes *time* and practice; this program provided the time that is usually not available in credential programs. Students of this program had the advantage of supervision during more of their learning process than do most student teachers who complete their second year of teaching in the field on their own.

Procedural Aspects

There were some concerns about procedural aspects of the program and the credentialing process. One student who was interviewed was frustrated by the way that the university handled the distribution and instructions for the credential applications. It was felt that the applications could have been submitted at the beginning of the semester with the inclusion of "work in progress" and that the students who were on the fast track could thereby have been credentialed shortly after the verification of completed course work. Members of the program were not knowledgeable about application procedures and the Credential Officer at the university was less than helpful to student requests for help with the application process.

Summary

The program as a whole, however, was praised as being innovative and adapted to the unusual demographics of a class drawn from Laboratory professionals. Students particularly appreciated the flexibility the program provided to those with changing work demands and difficulties with their teaching assignments. All of the students who provided input for this monograph were grateful for the opportunity to have been a part of this pilot program and for the opportunity to contribute their scientific knowledge and expertise to the field of teaching. They sincerely hope that the program will be continued.

A Science Credential Program for Professionals: Summative Evaluation Results

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The evaluation component of the Lawrence Livermore National Laboratory/San Jose State University Physical Science credential program consists of two elements: a course by course survey of student opinion of the overall effectiveness of the instruction including particular facets of instruction and written comments about any aspect of a course, and an open forum for students to critique any part of the program.

Overall Effectiveness of Instruction

The course by course survey used two instruments to gather information about instruction. One instrument, a five point normative scale, was employed for four courses and the other, a four point criterion scale, was used with three courses. The instruments also vary in the statements used to evaluate instruction. The instructions to students and two instruments are presented on the following two pages.

Comparison to Campus Instruction

Since the inception of the program in spring of 1993, seven course surveys were conducted. A total of 115 ratings were given by students. To compare the overall effectiveness of all the courses to courses taught at the university, the overall scores on the four point scale were converted to a five point scale value by extrapolation. The resulting mean for overall teaching effectiveness was 4.40. Other descriptive statistics are listed in Table 1.

Five and Four Scales

You are being asked to provide anonymously your opinion of the effectiveness of your instructor. Only the ratings of the class as a whole will be reported to faculty; individual student ratings will not be identifiable. Your responses will be used to determine whether modifications in this course are warranted.

Key: 1 = Far Below Average 2 = Below Average 3 = Average
4 = Above Average 5 = Far Above Average

This instructor(√):					
Made course requirements clear	1	2	3	4	5
Collected enough information to grade accurately	1	2	3	4	5
Explained the grading criteria	1	2	3	4	5
Helped me learn course materials	1	2	3	4	5
Showed concern for adult learners	1	2	3	4	5
Engaged me in a process of inquiry	1	2	3	4	5
Increased my understanding of teaching	1	2	3	4	5
Was well prepared for class	1	2	3	4	5
Used class time effectively	1	2	3	4	5
Used experiential learning	1	2	3	4	5

Overall effectiveness of this instructor is:

Key: 1 = Poor 2 = Fair 3 = Good 4 = Excellent

This instructor(√):				
Gave interesting lectures, presentations	1	2	3	4
Taught material relevant to teaching	1	2	3	4
Used class time effectively	1	2	3	4
Was well organized	1	2	3	4
Interacted effectively with students	1	2	3	4
Communicated clearly	1	2	3	4
Increased my interest in the subject	1	2	3	4
Made course requirements clear	1	2	3	4
Improved my evaluation skills	1	2	3	4

Overall, this course was:

Table 1

Descriptive Statistics for Seven Rating of Overall Teacher Effectiveness

Mean	Standard Deviation	Standard Error Minimum	Maximum
.33	.12	3.9	4.75

The mean for overall effectiveness is higher than the mean for all University courses (4.2), equal to the mean for the College of Education courses(4.4), and slightly lower than the mean for Teacher Education courses (4.5), but not significantly different from Teacher Education courses (paired t value = .79, p = .46, for six degrees of freedom).

The frequency of the ratings for overall teacher effectiveness are depicted in Figure 1. Four overall teacher effectiveness scores that are equal to or greater than the same value for the Division of Teacher Education and the College of Education, and five scores are greater than the same value for the University.

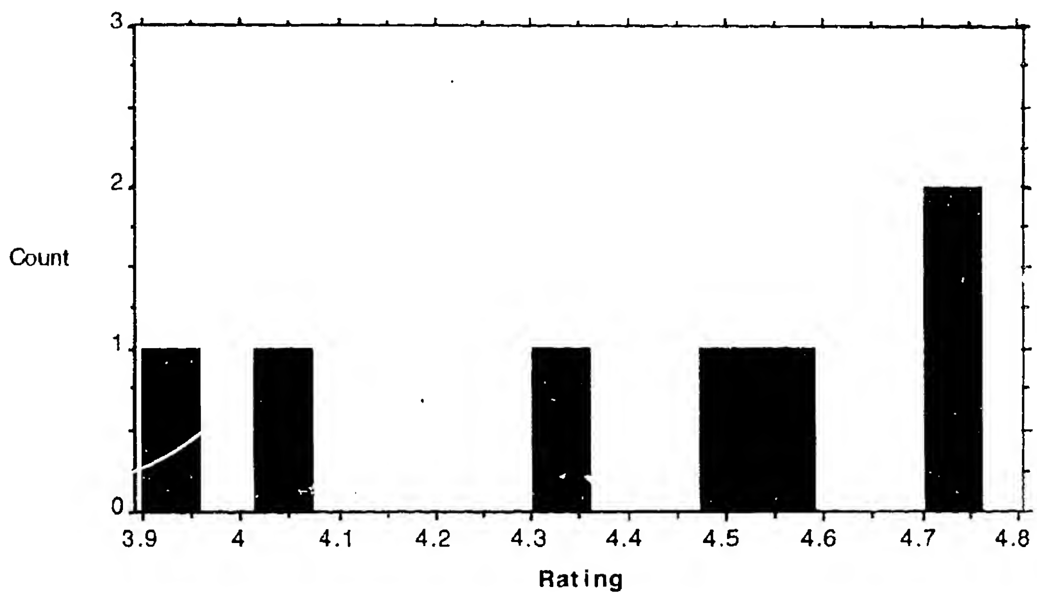

Figure 1 Distribution of Overall Effectiveness Ratings

Eavesdropping on the Thoughts of Students

Here are selected student comments made as students preceded through the course of study.

On Philosophy and Ethics

It was not an easy task to "push" math/science oriented people into discussions of social issues. The instructor knew his subject well and helped me understand aspects of teaching (values, ethics, funding, cultural differences) that I would not have considered without this course. I appreciated his insight and I'm convinced his teaching will help my classroom success.

Consideration was not given to the audience being highly intelligent science and math types. A little bit too much emphasis on English.

It was difficult for many students coming from a rational, critical area like the sciences to relate to a humanities course.

A good deal of work was required, more so than any of the other courses, but the course was very good and through the work I was required to explore areas that I otherwise might not have explored. The instructor forced me to learn and I learned.

I was dubious of the relevance of this course in the beginning; I was also concerned that the amount of reading and outside research was too great. I was pleasantly surprised.

The instructor did not seem to realize that he was giving this class to math and science students only. He expected us to write essays as though we were English majors. I do not see how this course can help me become a better math teacher. I did not enjoy the class, and I still question its necessity. We are not planning to become administrators, just part-time math teachers.

At first I thought that this course was going to be the one the ED school graduates always warned me about, but it grew on me as it went on. I surprised myself by learning more than I thought I would by just working on the material and project. Not just to understand the arguments but to really reflect on whether they might be more nearly right than he supposes.

On Mainstreaming

Given that I came in very skeptical of mainstreaming, I really learned some things that would help me.

The instructor made me alot more comfortable with the idea of mainstreaming. I think I can effectively include many students when I questioned my ability to include before.

The instructor was extremely effective in getting across her message, not only to the mind but also to the heart. I think the instructor was an excellent role model for a teacher.

I examined my beliefs and they changed as a result. A good overview of the problems and possible solutions with mainstreaming.

The course pierced my mind completely to a subject I didn't know anything about.

On Observations

I would like a chance to see some real "master teachers" at work. Choosing randomly has some very real drawbacks. Sometimes only the "bad" teaching practices are viewed. Is it better to see many different teachers or one as the year progresses? Time [is] a factor that limits [the] number of school visits. [I] would like a chance to sit down and discuss the reality of a teaching day with a variety of teachers.

On Concepts in Science

The course helped me understand science and get a better view of the big picture. I think my teaching/speech skills are noticeably improved.

I really enjoyed this class. I think it would be a great class for parents in general. If you wanted to get more students you could just advertise it as a class about education.

Would like one more class to clarify some concepts - perhaps a list of reference books to read (or not) on aspects of teaching, discipline, etc.

It would be useful to find some way to collectively summarize the techniques and notions learned by us in the teaching exercises. It would be nice to have time for the whole class to see and review specific very strong teaching segments to identify and

reinforce effective approaches. It may be that time would not allow this diversion. I learned several useful approaches by critiquing other individuals and I feel the whole class would have benefited by seeing several of the best efforts.

On Student Teaching

This course was a good step for me to get some of the beginning information about teaching. I have used the material often. The only difficulty that I experienced was in the student teaching portion. I was not really teaching my own plans, but those of the master teacher. It was difficult to try some of the concepts which were presented in class.

Narrow choice of teachers to work with - would be better to have a good example of teaching to follow or at least observe occasionally if not actually work with. Perhaps longer class time so that some part could be spent talking over teaching experiences each week and then not lose class time for learning concepts involved with teaching and learning.

I found my university supervisor to be wonderfully insightful and concrete in his suggestions for improvement and refinement of my teaching methods and presence. He engendered a feeling of possibility in me - helped me to step outside of myself and see how I really am and what I am capable of with experience and practice. I'm not really sure what we are being evaluated on; I'm not sure it matters. I have worked my hardest and presented daily and weekly my best - I believe I have done well. I have found this class to be formative and extremely positive. I count myself lucky to know these instructors.

I enjoyed almost every minute of it. It made me feel comfortable about going into a classroom and working with real kids. As I applied more of the methods I learned I could see the kids starting to come with me. I don't think we need much practice in making presentations.

The interaction with the instructors during the student teaching aspect was most valuable. In hindsight the inquiry approach presented was more valuable than realized. Simple, effective lessons directed at a concept could be understood and that understanding transferred to our own student teaching. Their experience in the educational field was obvious and they encouraged us to expand ourselves and attempt to be effective teachers.

On Evaluation

I enjoyed this course because it was taught with clear objectives. It made me a believer in stating clear, concise, and meaningful objectives.

It is interesting to note that this instructor used techniques and advocated ideas that are diametrically opposed to those used and advocated by other instructors. This gave us a wide range of points of view, but will force us to think for ourselves.

This was a very useful course. I would like to know a bit more of the underlying theory of Kuder-Richardson 21 and the equation defining standard error of measurement.

On Working and Going to School

I feel the accommodation to full-time working students was attempted very thoughtfully but remains a difficult and unsolved problem: how to maintain a high enough course workload without burning out the students? It is very tempting to quit the program due to time and schedule demands of full-time work and school. (But I am not.)

My only concern with the course/student teaching combination for full-time scientists is the amount of time required. This class coupled with 20+ hours of student teaching, 30+ hours of observation, and all the attendant lesson plans (the bulk of the work) was very difficult at times considering we have full-time jobs and make up the teaching/observation time with later hours at the Lab. I don't know the answer but I am indeed worried about the time that will be required next semester when we have a full class to teach *every* day. It is the lesson plan preparation that is the real time consumer and we must prepare a large number ahead of time to be on top of things. Perhaps some effort can be made to address these special time problems of the full-time working scientist wanna-be teacher.

The student teaching is great; it is the preparation time that is "troublesome" since I am working full-time. I spend at least 3 hours a day just to go to class, teach the class, and coming back to work. This does not include the preparation for class, grading exams. and homework. Next semester I won't be student teaching at all if I can help it.

When travelling it would be helpful to have a copy of the information handed out in class or the assignment page. Upon return it is sometimes difficult to get information

in a *timely* manner so as to participate along with everyone else - not a really big item, but a thought.

On Instructors

The instructors have very different and contrasting yet complementary styles and drove home a number of critical aspects of good teaching.

The instructors complemented each other very well. My personality fits one instructor's style better than the other, but the other instructor "woke me up" to a more dynamic approach. The most important thing I have gained this semester is confidence. Between my teaching experience and classes, I feel significantly better prepared to teach high school chemistry. The characteristics I like about the instructors are that they are sincere and they practice the teaching techniques that they suggest.

The instructors of this course have been unusually creative in pulling us through various experiences to arrive at a planned moment of enlightenment. One moment we were students experiencing a lesson and the next moment teachers implementing the methods used in the lesson with the background of learning from that method. I have looked forward to this class with anticipation - what is next? What will I learn tonight?

The best part of this course and the most useful were the discussions that came from the many years of actual teaching experience of the instructors. They not only told us what they thought we should do as teachers but they also told us how it worked when they tried it. They also were able to relate well to the problems we are experiencing in the classroom.

The instructors complement each other well. It's a dynamite combination of academic and classroom experience, theory and practical applications.

A Mathematics Credential Program for Professionals : Formative Evaluations Results

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Purpose and Plan

The Single Subject Credential Program in mathematics at Lawrence Livermore National Laboratory is designed to open up careers as secondary school teachers for current employees of the laboratory. In a time of cutbacks in defense funding, both the Lawrence Livermore National Laboratory and the Single Subject Credential Program at San Jose State University which sponsors the program believe that at least some scientists, mathematicians, and engineers who have pursued careers at the Laboratory may be able to make a successful transition into teaching. Approximately 15 students have completed the first year of the two-year program.

In order to accommodate the special needs of working professionals, the mathematics credential programs at Livermore (a credential program in science is also offered at the Laboratory) are specially modified from versions of programs currently offered at San Jose State University, and indeed draw on the same faculty. Both the science and mathematics programs at Livermore have been approved by the Commission on Teacher Credentialing.

This evaluation was commissioned by the mathematics program and so will be limited to that focus. It was designed to provide a formative rather than a summative picture of the program and, thus, concerns itself more with processes than with products and with discovering potential weaknesses that can be addressed. The program is currently entering its second year. It is directed by Dr. Billie Risacher, a faculty member in the Department of Mathematics and Computer Science at San Jose State University.

The report begins with a comparison of the Livermore program with the mathematics on-campus credential program at San Jose State University. Significant differences between the programs will be considered in light of the special needs the Livermore program has been designed to address. The remainder of the report concerns the results of two surveys completed by students. The first of these surveys, normally given to students at the end of the program at San Jose State, entails an evaluation of the quality of courses taken and of

preparation provided regarding 22 specific competencies related to teaching. Results of this survey need to be interpreted cautiously since students had completed less than half of their program at the time they filled it out. The second survey was designed specifically for this evaluation study. It consists of nine open-ended questions that range in focus from students' perceptions of their own special needs to the success of the program in meeting these needs, the quality of treatment of various core topics, and the effects the program is having on students' perceptions of themselves as future teachers.

Program Design

Because the Livermore program serves a population of students different in some respects from students who typically enroll in the on-campus program at San Jose State University, certain modifications have been made in program design to help meet the perceived needs of that population. Special needs relate primarily to subject matter preparation, familiarity with contemporary educational issues and practices, and work commitments at the Laboratory. Many of the students in the program, particularly those who have pursued careers in science or engineering, do not meet California standards for subject matter competence based on their academic background and are thus required to take and pass PRAXIS Exam (formerly known as the National Teachers Exam) in mathematics. Moreover, even those students with a strong academic background in mathematics have often been out of school long enough that knowledge of certain topics needs to be refreshed. Familiarity with contemporary issues and practices in education is desirable for students entering teacher education programs; however, students entering education as a second career have often been away from schools for several decades, remember practices that are no longer favored (or in some cases even feasible), and experience considerable anxiety over their abilities to work effectively with contemporary adolescents. Finally, the Livermore students continue to hold down full-time-jobs at the Laboratory. Time available to pursue credential studies is quite limited, especially when family commitments are taken into account.

Admissions requirements are essentially the same for the two programs. With respect to the curriculum, the on-campus program for the preliminary single subject credential consists of eight courses (26 semester units). Students typically take either two or three semesters to complete the program. During the first semester, mathematics credential candidates normally take Socio-Humanistic Foundations of Secondary Education Psychological Foundations of Secondary Education, Student Teaching I, and Secondary School Mathematics. Students take Student Teaching II and Student Teaching III during their second semester. Content Area Reading and Evaluation may be taken either semester.

The Livermore program is designed to take four semesters. the first of which is taken up with prerequisites normally satisfied by campus program students prior to beginning the eight-course sequence described above. Courses taken by Livermore students during that first semester include a survey course covering mathematical concepts foundational to the secondary school mathematics curriculum and a pre-professional experience focusing on classroom observations supported by readings and discussion. During the second semester students take Secondary School Mathematics and an abbreviated version of Student Teaching I, two units rather than the four units taken by on-campus students. During the third semester, students take an augmented version of Evaluation, three units rather than two units, the third unit devoted to issues of classroom management. They also take Student Teaching II. Finally, during the fourth semester, students take Foundations of Secondary Education, a condensed version for three units rather than six and consisting of the two foundations courses on-campus students normally take during their first semester. They also do their final stint of student teaching.

Adaptations of the program for Livermore were intended to address students' special needs. Prerequisite courses. for example, address both the need for students to review and refresh subject matter knowledge and to acquaint themselves with contemporary practices and problems in the secondary schools. While students in the San Jose State campus program often take these courses, neither is required. Prerequisite courses aside, however, the Livermore program entails considerably fewer units (19) than does the on-campus program (26). Presumably this has been done with the intent of accommodating time limitations on the part of students. With the required prerequisite courses taking up the first semester and students continuing to work full-time but with a reduced course load as implemented in this program, students could expect to finish within four semesters. Whether or not four semesters represents some practical limit on the length of time students are willing or able to commit to pursuing a credential is unclear.

It is clear, however, that a reduction in the number of classes (six rather than eight) and in the number of units requires both the repackaging of curricular elements and a reduction in emphasis accorded at least some oi those elements. The Livermore curriculum reconfigures student teaching over the first two semesters and is comparable to the on-campus requirements. Both units (from six to three) and courses (from two to one) have been reduced in educational foundations. An examination of the courses shows a decided emphasis on issues normally covered in the Socio-Humanistic Foundations class taught in the on-campus program and in both content and emphasis this course appears more comparable it. There is little indication, however, that issues normally covered in the Psychological Foundations course receive any direct treatment in this course but appear to receive some indirect treatment. For example, the

methods course devotes one class to learning theory, one to classroom management, and one or more to problem solving, and an additional unit has also been added to the evaluation course to handle classroom management issues. Nowhere in the curriculum is there evidence of direct treatment of adolescence and adolescent development or of individual and group differences. Finally, Content Area Reading, required of all students in the on-campus program, has been omitted from the curriculum at Livermore. Presumably it is the intent of the program to provide some coverage of topics commonly covered in that course in other courses (e.g., reading comprehension, concept acquisition, writing across the curriculum, language development, second language acquisition, sheltered instruction, bilingual education, etc.). However, neither the syllabi nor the course descriptions directly reference these or related topics.

Areas of concern, then, relate to coverage of topics in the areas of psychological foundations and language. As noted earlier, an abbreviated program necessarily must pay diminished attention to some issues. Which issues and how diminished their treatment, however, is not always evident a priori and thus a process for systematically reviewing those choices is desirable. In this instance some domains (instructional methods, evaluation, and social-humanistic foundations) appear to have been retained unabridged from the on-campus program while other domains receive considerably less attention. I believe that it would be desirable to look closely at how these decisions have been made and to formulate an explicit rationale for such choices.

Survey of Competencies and Courses

The first survey referred to in the introductory section of this report concerns students' evaluations of how well the program prepared them with respect to 22 specific competencies--competencies on which they themselves are evaluated by cooperating teachers and university supervisors during their student teaching. It also asks them to make global ratings of program courses. As noted, this survey is typically completed at the end of the program and so it must be understood that the current data is based on an incomplete picture of the program on the part of students. Therefore no effort is made to compare results with those obtained on campus and caution is advised in interpreting results. The fact that only 12 surveys were collected adds to the need to interpret conservatively.

The competency portion of the survey allows for four responses concerning degree of preparation provided by the program: "very well prepared", "well prepared", "poorly prepared", and "no opinion". Items yielding the highest proportions of positive evaluations ("very well prepared" or "well prepared") include: "employ diverse instructional strategies, activities, and materials for a variety of learners" (100%); "prepare and teach complete and appropriate

lesson plans" (100%); "maintain positive rapport with students" (92%); "communicate effectively by presenting ideas and instructions clearly and meaningfully" (83%); "motivate and sustain student interest and involvement" (83%); "evaluate and grade students accurately and fairly" (83%). Overall, at least 75% of students responded "well" or "very well" on 14 of the 22 items on the scale. The majority appear to be competencies related to methods and early field experiences. Five items show at least one third of students indicating a belief that they have been "poorly prepared". These include "manage unacceptable classroom behavior" (67%); "establish and maintain positive parent/community relationships" (50%); "identify student learning needs and plan appropriate instruction" (50%); "work effectively with students with special needs/handicaps" (33%); and "articulate defensible educational philosophy" (33%). Most but not all of these statements pertain to competencies covered in course work not yet taken (e.g., Evaluation and Classroom Management, Foundations of Secondary Education). Some pertain to issues handled in the Psychological Foundations of Secondary Education course taught in the on-campus program. The response to one other item stands out in similar fashion-- "provide limited English proficient students with sheltered instruction" shows fewer than half of the respondents judging themselves to be well prepared; a substantial number responded "no opinion".

Ratings of individual courses should probably be discounted inasmuch as several respondents appear to be confused as several students rated courses they had not yet taken. Although data for particular courses is probably not trustworthy, the overall picture appears to be one of general satisfaction with the course offerings taken in the first year of the program.

Free Response Evaluation Survey

As noted earlier in this report, a special "free response" survey of students was designed especially for this evaluation. The survey (included in the Appendix) consisted of nine questions ranging from students' reasons for pursuing a teaching career to perceived strengths and weaknesses of various aspects of the program. The survey was introduced to students in the program by the author during an hour-long session preceeding one of their classes. The hour-long session was used to review the purpose of the evaluation (to provide formative information that would be helpful in deciding how to shape any future implementations of the program) and to generate some discussion relevant to each item. The intent was to create something of a "focus group" atmosphere that would stimulate thinking on the issues covered in the survey. Students were then asked to complete the survey on their own (anonymously) and return it the following week. Ten students completed the survey.

Question #1: What attracted you to a career in teaching? How long have you been ' ::ested in becoming a teacher?

The majority of respondents emphasized their interest in pursuing a second career (in some cases after retirement from the Laboratory). One cited time off during the summers, more time with family, and opportunities to travel. Most, however, indicated a long-standing interest in teaching supported by previous teaching or coaching experiences, the influence of friends or relatives, the satisfaction of working with young people, and/or a desire to contribute something to the community. A point that came through clearly in the round-table discussion but that was not reflected in written responses was that without a flexible program of this kind, many could not envision themselves pursuing a teaching career.

Question #2: What significant reservations or concerns (if any) did you have before beginning this program (e.g., about the program, yourself, schools, students, money/time, etc.)?

Overwhelmingly students cited time constraints as the most vital concern. Time was perceived to be problematic in two ways. First, there was the length of time needed to complete the program. Two years seemed daunting to at least a few students. Second, students worried that they would be unable to find the time during the program to satisfy its requirements. Family commitments, job demands, and the need to adjust to doing school assignments figured prominently in this second concern. One respondent worried that participation in the program might negatively affect his or her job performance evaluation, the clear impression given that "the boss" might be inclined to take him or her less seriously. Individual responses cited financial concerns, student and parent attitudes toward teachers, subject matter competence, and the concern that the intellectual challenge may not be enough. More prominently represented in the round-table discussion were cases of perceived family opposition, horror stories about students and school administrators, and indecision about whether teaching would make for a good career.

Question #3: In what ways has the program succeeded in meeting your needs and interests? What do you perceive to be its particular strengths? (You may wish to consider how the program is organized and delivered, the academic curriculum, field experiences, support provided by faculty, the Lab, etc.)

A number of points were consistently raised. First, flexibility in both program design and implementation (e.g., assignment due dates) was strongly appreciated. Dr.

Risacher was especially singled out by students for praise. Her willingness to be flexible, her ability to solve problems, her accessibility, and her skills as a manager were commended in both the written surveys and most especially during the round-table discussion. Appreciation was also shown for conveniences such as the Lab paying tuition, the program being held in Livermore, and the fact that the program had been condensed and streamlined. A large number of students praised the Methods course, particularly in the round-table discussion. It was credited with providing many good teaching ideas and opportunities to try them out. Finally, a number of students expressed positive feelings about the Concepts in Mathematics course, both in terms of refreshing old concepts and in preparing for the PRAXIS exam.

Question #4: In what ways is the program failing to meet your needs and interests? What do you believe to be its particular weaknesses?

Two respondents indicated no areas of weakness (one simply stating, "I find this a strong program"). One commonly cited issue had to do with the Concepts in Mathematics course which several respondents indicated failed to provide sufficient help on topics needed for the NTE (PRAXIS). There seemed to be considerable uncertainty about the purpose for this course. A significant number of students indicated a belief that it was or should be exclusively a test-prep course. Others perceived the goals to be broader but felt that more attention should be given to topics actually taught at the high school level. The other primary area of concern had to do with student teaching and particularly the placement process. Some found the initial need to find their own placement sites to be onerous. Others expressed fears of being placed in classrooms incompatible with program philosophy or with teachers inhospitable to them. A number expressed that the program should seek out exemplary host schools and cooperating teachers for their student teaching experiences. Other issues (primarily raised during the round-table discussions) focused on lack of attention to classroom management issues (treated like "Hints from Heloise" according to one student), lack of attention to the "dynamics of schools" (roles of teachers, how departments work, etc.), and frustration with the "fuzziness" and "ambiguity" of the state standards/frameworks and their failure to "match reality". Several students expressed a preference for older standards.

Question #5: What issues, topics, or experiences (if any) do you believe deserve more attention in the program? How and to what extent would you like to see those issues, topics, or experiences enhanced?

The primary focus for those who answered (or were responsive to) this question had to do with classroom management and how to deal with discipline problems in the classroom. As an aside, it should be noted that this is a perennial and nearly unassuagable concern of beginning teachers. It is also a topic that will be covered later in the program, as were test development and grading, two other areas mentioned. Several respondents mentioned curriculum partly, I think, expressing dissatisfaction with the state framework and partly expressing a desire to know how the curriculum is reflected in actual classroom practice. There appears to be some suspicion that what really happens in classrooms is not represented in the official document. Finally, a couple of respondents indicated a desire to receive more preparation for the NTE.

Question #6: What issues, topics, or experiences (if any) should receive less attention or should be handled differently? How would you like to see those issues, topics, or experiences dealt with?

Most of the comments related to the Concepts in Mathematics course. Some suggested that it focus exclusively on NTE preparation. At least one person indicated that the course should be made optional. One simply indicated that the course needs to be better defined. A couple of respondents commented on specific content of the course ("less abstract algebra, more probability theory", "history of math is not necessary"). One person indicated that micro-teaching in the methods course was not helpful because it was "pitched to the wrong audience". One complained that the NCTM standards "contain a lot of psycho-babble".

Question #7: Please comment on the adequacy of preparation provided by the program in the following areas. Include any suggestions you have for improvement.

Classroom Management. Most of the respondents indicated insufficient preparation (to date) in the area of classroom management, although two respondents indicated that they felt well prepared while one expressed general satisfaction with respect to all the topics listed ("I learned something new in each case").

Learning Processes. All but one respondent felt positive about coverage of topics in learning. The one dissenter felt that more needed to be done with respect to "cognitive thought processes".

Motivation. Again, the majority expressed satisfaction with their preparation in this area. One respondent expressed concern that some of the advice given with regard to motivation ("use positive reinforcement") conflicts with practice.

Adolescence and Adolescent Development. Overall, respondents indicated that the treatment of issues related to this topic was "weak" or "non-existent". No one gave any positive indications in this area.

Language and Culture. Response in this category was mixed, although the majority of those who did respond indicated that treatment was inadequate. About half failed to comment. One expressed negative feelings about "diversity training".

Math Content. Most who responded indicated that more emphasis should be given to the content taught at the high school level and that too much attention was directed to college level math. Several, however, indicated a high level of satisfaction.

Math Curriculum Standards/Framework. One or two again complained about the framework, but most who responded indicated a desire to devote more attention to scope and sequence.

Question #8: How, if at all, has your view of yourself as a teacher or of teaching more generally, changed since you began this program?

By far the most common response to this question was that self-image and confidence in the ability to teach successfully had improved. Approximately half of those responding so indicated. Several also noted that the experience has reinforced their desire to become a teacher. Increased respect for teachers and the teaching profession was raised by at least two respondents. One indicated greater satisfaction from tutoring than from teaching. Another confessed to difficulty motivating students. Finally, one student discussed insights into the teaching/learning process ("I need to allow students time to discuss and think things through...I used to think I had to teach constantly for the whole period").

Question #9: Please make any other comments you believe would be helpful to us in evaluating this program.

A variety of individual responses were given to this question. They are reported here by individual respondents.

1. Noted the importance of the compatibility of the cooperating teacher with the philosophy of the program--mine emphasized rote drills; small groups and open-ended problems didn't work in this class.

2. Great program, well taught--glad I did observation before student teaching; liked working with my supervising teacher.

3. Transition into teaching was well prepared by San Jose State faculty. Had a good cooperating teacher who was willing to experiment; other teachers had negative views of the framework.

4. This program is great. I appreciate the flexibility and convenience. The state, however, has too many requirements and makes it difficult for people to become teachers.

5. Might expand program to three years and tailor it to individuals; difficult for students when teacher and student teacher conflict in style.

6. Shortcomings will lessen in time.

7. Good idea for tenured teachers to take this type of course, especially second semester.

8. Expected more concrete explanation of mathematical knowledge goals; NCTM guidelines more concerned with politics and social work than academic achievement. As a whole the program was a worthwhile experience; learned about different viewpoints on teaching and discovered I liked kids.

Conclusions

Overall, results of the surveys indicate a relatively high degree of student satisfaction with the program. Students appear particularly impressed with how accommodating the program has been to their individual and collective needs. The program director has been praised by a number of students for her flexibility and problem-solving skills. Program faculty have also received considerable praise from students for the quality of their teaching and their responsiveness to student concerns.

Several issues, however, would appear to deserve special attention. First, the consolidation of the program has required some choices to be made about topics that will receive less attention than they do in the on-campus program. Many psychological issues,

particularly in the areas of motivation and adolescent development, receive scant attention in the program. Similarly, issues related to language (and particularly working with limited English-speaking students) are given minimal treatment at best. Second, there appears to be considerable confusion over the purposes served by the mathematics review course. It may be that it tries to serve too many ends that are not fully compatible. Third, student teaching placements are critical to the success of the program and need to be better planned. In particular, it is essential that cooperating teachers model and endorse best practices as they are currently represented in the rest of the program. Moreover, cooperating teachers need to be willing and enthusiastic mentors. Apparently, several have not met these criteria. Finally, my discussions with students and their responses to the questionnaire have led me to believe that some experience significant conflicts between their own beliefs and values and those they perceive to be endorsed by the program, by professional educators, and by the Department of Education of the State of California. This dissonance needs to be confronted and explored throughout the program.

These concerns noted, the program gives every indication of being in good health and of meeting most of the needs and expectations of students. New programs necessarily experience some problems that need to be addressed. Those cited here are of the sort that could be readily handled in preparation for the next cohort of students.

Evaluations, Conclusions, and Implications

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The various writers of this work have addressed most of the concerns posed in the overview chapter: concerns of the university, the Laboratory and of the students. In this summary we will try to further answer these questions by looking at some additional data. In addition, at this point in time, the directors of the science and mathematics programs have the advantage of hindsight and will offer reflections on the goals and progress of the program as the completion of the program by the first cohort. As part of these discussions, we will also consider the implications of our experience on the planning of future programs for career scientists and engineers.

Number of Interested Laboratory Employees

An initial motivation of the university was to create a teacher training program designed especially for experienced persons in the fields of mathematics and science. The goal was to increase the number of qualified science and mathematics teachers. The hope was that this was an opportune time to do so given the current downsizing of the defense industry. However, we encountered a great difference in the number of Laboratory employees who originally indicated an interest in the teacher credential program compared to those who actually enrolled in the program. Lab personnel originally estimated that approximately 400 persons were interested in a science or mathematics teacher credential program, many of whom attended noontime informational meetings with university professors who presented the details of the program and answered questions. However, we began the program with approximately 26 science and 16 mathematics students. To investigate the reasons why many employees did not pursue the teaching credential, a subset of about 20% of the 170 employees who requested an information packet on the math program was selected at random and interviewed via telephone by a Lab Human Resources employee. The following results were obtained:

Part 2: A Case Study

Question 1: Why were you interested in the teaching credential program?

Long-time interest	8
Retiring/Part-time	13
Prefer college level	3
Other commitments	1
Flexibility	1
Exploring	1

Question 2: What factors account for your decision not to pursue the opportunity that is currently being offered?

No relevant background	1
Other commitments	19
No interest in math	2
Prefer to teach higher level	1
Low salary	1

Question 3: What changes in the program would encourage you to pursue a teaching credential if the program was offered again?

Change in time constraints	4
Opportunities other than math	3
Prefer college level	2
Satisfied with program	6
Simplify the program	3

Question 4: Are there other factors that would encourage you to pursue a teaching credential?

If time permitted	2
Challenge	1
Transportation	1
Completion of current course	1
No relevant background	1

Question 5: Do you feel that your experience at LLNL would contribute to your being a good teacher? If so, how/why?

Yes, able to apply in classroom	14
Yes, able to teach math or CS	1
No, students are immature	1

Question 6: Should we contact you if we decide to offer such a program in math or science again?

In the future	4
Lowering requirements	1
Send application	5
In other areas (not math)	3
Time	1
Not interested	2
Not sure	2

Question 7: Other comments that might shed light on the subject.

Work commitment	2
Good program	4
Prefer lower level	1
Focus on math	2
No comment	4

We note that most of this group was interested in the teaching credential program as a possible retirement activity, or they had a long-time interest in teaching. Another important indicator is given in Question 5 where almost all the employees felt their Lab experience would help them be good teachers. It would seem that attracting individuals either as retirees or as people who have always wanted to teach and who believe they h.. e work experience that will help them be good teachers is desirable. On the other hand, the overwhelming reason they did not pursue the program was that they had other pressing commitments. We found that the candidates that we did attract were people with many interests and commitments as well as high personal standards for their involvement. In other words, we did not find the credential candidates to be stereotypical "nerds" or antisocial individuals. If we assume that most of the Lab employees are heavily committed to work, community, and family activities, as were the

credential candidates, we can conclude that entering a credential program while they are still full-time employees appears to be unrealistic for most of them. This conclusion is supported by Question 3 where many indicated satisfaction with the program but cited "time constraints" and "simplify the program" as factors.

Credentialed Teachers from the SJSU/LLNL Program: Quantity and Quality

As of the date of this writing, five of the remaining 16 science credential students who began the program have finished. The remaining 11 students need to complete only their student teaching component to finish. Considering quality along with quantity, it should be noted that all five who have finished received strong evaluations from the university supervisor who monitored their final student teaching. Two of the five were regarded as exemplary teachers. In the opinion of this author, these five students as a cohort are more talented and mature as science teachers than is the large cohort of graduates from our San Jose State on-campus program. This is largely because the on-campus program contains some much younger students who have just received baccalaureate degrees and who lack experience in science applications as well as the maturity of a working professional.

Of the remaining 11 science students who have not yet finished, it is likely that some will never enroll in student teaching because of their job responsibilities at LLNL. It is also possible that those who wait for a few years or more will lose the confidence to assume the role of classroom teacher, which they all now know is a highly challenging job. Because knowledge erodes from memory over time, we expect those who wait long to student teach may revert to "teaching as they were taught", rather than use the newer approaches to teaching and assessment that were advocated by the course work in this program. Evaluating these students as they finish will contribute to our on-going longitudinal study of this credential program.

In the mathematics program after three years, six students have finished the program from the original cohort of 16 students. Three more are currently finishing the last requirement of the program. Of the original 16 students, two withdrew for health reasons (pregnancy and carpel tunnel syndrome); two had increased responsibilities or conflicts with work responsibilities; one decided he did not enjoy classroom teaching; two had difficulty in passing the national exam in mathematics; and nine have or are expected to complete the program this year. At this time three students are teaching in schools, one is planning to begin teaching within the next year, and two more are nearing retirement age and intend to pursue teaching within a few years. One other intends to teach part-time within the next few years and continue her LLNL position.

As in the science program the quality of the mathematics students has been exceptional, both in their course work and in their work in the schools. However, the completion rate is certainly less than we had hoped for. The cooperating teachers from approximately 30 classroom placements as student teachers either in a Phase I or Phase II position have given the student teachers the highest grades and praise with only two exceptions. For example, one teacher's comment on the final evaluation form said "[the student teacher] was always willing 'to go the extra mile' to provide creative and varied lessons for his students. He was always patient and willing to listen to student concerns and suggestions." A university supervisor from another campus who was not associated with the program commented, "It has been my pleasure, as a supervisor for SJSU, to observe ----- [she] is [a] poised, confident, mature individual who exhibits a strong professional approach to teaching. She demonstrates knowledge of the subject matter of mathematics and delivers instruction in a clear, formal manner. ---- [She] is concerned about student progress and works with them on an individual basis as well as supervising group activities in which students share knowledge." Yet another student teacher receives these evaluation comments: "(His) knowledge of course content and objectives are exceptional, as is his enthusiasm and effort. He is especially interested in making math a fun experience for his students. The students respect him and feel comfortable in asking for help."

Many of the principals and teachers have clearly recognized the student teachers as a resource to bring the use of computers and new ideas into their curriculums and schools. In almost all cases, the LLNL credential graduates are highly praised by the local schools and are viewed as desirable additions to their mathematics teaching faculty. The final evaluation scores for their student teaching were of the highest rating in over 75% of the categories with the remaining scores as "standard" in almost every case. There were only two instances where there were concerns by the teachers and by the university supervisor. In both cases the situation seems to be that the student teacher is quite effective with one level of student, either high school or middle school, but does not do well or enjoy working with the other age group. As the university supervisor observing the student teaching, I suspect that other factors were also involved, namely the particular class involved and personality issues between the student teacher and the cooperating teacher. In my opinion, the LLNL students have a considerable advantage over the typical campus student in terms of maturity, professionalism, working knowledge of subject, willingness to work, confidence, and ability to work with others to name a few important characteristics of a teacher.

Program Effectiveness: Opinions of the Students

Another concern was how well this program would equip these students to teach. It appears that an appropriate summary is the quote from the article by the science students which states: " All of the students who provided input for this monograph were grateful for the opportunity to have been a part of this pilot program and for the opportunity to contribute their scientific knowledge and expertise to the field of teaching. They sincerely hope that the program will be continued." On the end of program survey, which evaluates 23 objectives, the students were asked, "How well did the credential program prepare you to: ---?" The graduating students indicated they were "very well prepared", the highest rating on the form in the majority of categories. In some instances they rated the program as "well prepared". None rated the program as "poorly prepared". The distribution of these ratings between "very well prepared" and "well prepared" does not reveal any area of special note; rather, the overall conclusion is that students perceive the program as very effective in preparing them for the classroom. This compares favorably with the on-campus program where students have noted in particular that they were not adequately prepared for classroom management. I might speculate that the LLNL students themselves may be the determining factor here. It would seem that a program which attracts more mature and accomplished individuals yields the advantages of a classroom teacher that have been cited about the teachers of this program.

In rating the specific courses of the program, almost all of the ratings were in the "excellent" category, with one course rated as "fair" by about half the students. There were no "poor" ratings of the courses from this most critical and exacting group of students. We believe it was a strength of the program to offer courses in mathematics and science first as these courses were consistent with the expressed interests of the students. The rating and the informal comments from the students during the program further confirms this decision as the course with the lower ratings was an educational foundations or philosophy course. Comments from the students to both the directors of the program and Lab personnel indicated a negative attitude prior to and at the beginning of the foundations course. While most of the LLNL students began this course with a negative attitude, about half ended up rating it as a "good" course while the others gave it the "fair" rating. It is difficult to determine if this was a fair assessment of the course given the prior attitudes of the students going into the course. It would appear that these professionals posit more value to the practical aspects of the program: those directly related to classroom teaching. It should also be noted that many of the Lab students were very knowledgeable and had strong opinions on current educational issues, some of which were topics in the foundations course; thus, some thought that they did not need to be introduced to these issues.

Conclusions and Implications

Overall, both of the directors have been very pleased to have had the opportunity to work with the Lab and the LLNL credential students. From all indications, the Lawrence Livermore Na' ,nal Laboratory Human Resources Department seems quite pleased with the partnership with San Jose State University. Since the first two cohorts in science and mathematics, the Lab has initiated another cohort of science and/or mathematics credential students. A sufficient number of science candidates were interested and those classes have begun. We believe that a relationship of real trust between the SJSU and LLNL partners is apparent and a number of genuine friendships among faculty and students and Lab personnel have developed.

While the quantity of LLNL graduating credential students has not been as great as expected, the quality of their course work and contributions to the local schools has been extremely high. It should be noted that almost all of the Lab students have expressed a greater appreciation for the demanding task of teaching. We believe the increased awareness of educational issues and classroom teaching by the credential students will benefit the local schools in ways other than by direct classroom teaching. We know of several Lab students who are continuing their involvement with local schools through participation on school committees and school boards and in other voluntary capacities. It would seem that the success of programs like this one may lie more in indirect outcomes rather than in the actual number of students who become full-time teachers.

The credential program for Lab employees has resulted in many new professional contacts with teachers and administrators in the Livermore and Pleasanton schools, which are not in our normal service area. This program has also been an opportunity for faculty to work with teachers and observe students and curriculum in schools with a very different socio-economic and ethnic make-up from our normal service area. The university supervisors of the student teachers found numerous differences in the role and tasks of the teacher and in the curriculum of this geographic area as compared to the immediate area surrounding SJSU - another opportunity for professional growth.

The various faculty who worked in the planning and implementation of the SJSU/LLNL credential program have expressed many benefits from their involvement. This program has provided the faculty the opportunity to analyze the components and goals of the on-campus program and its strengths and weaknesses as we sought to adapt it to meet the needs of this special population. We believe the reorganization of the on-campus program was appropriate for this audience and was maintained in the second cohort of science credential students. The close working relationships and cooperation developed among faculty from education, science, and mathematics as they worked together on this program was another positive outcome.

Likewise, the exposure to a very different audience and a modified program, necessitating course modifications has been valuable professional experience for the faculty. In addition, evaluating, reflecting on, and writing about this program has provided the faculty opportunities for professional growth. This program and the SJSU/LLNL teachers have received much favorable attention in the local newspapers and from the State of California "Day of the Teacher" recognition awards where several of the program's teachers have been honored. These recognitions have acknowledged the Lab and SJSU an innovators who are trying to improve mathematics and science teaching. This type of recognition has been a morale booster and has encouraged the university to continue its efforts in revising and improving programs to meet the needs of the individuals and communities we serve.

Appendix

Application Packets

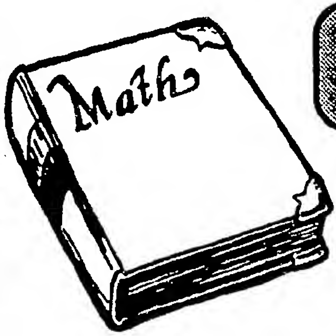
LLNL/SJSU Program
SJSU Program

Appendix

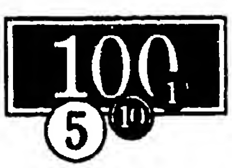
Application Packet: LLNL/SJSU Program
Application Packet: SJSU Program

Single Subject Teaching Credential Program

San Jose State University
Lawrence Livermore National Laboratory



Application and Information Packet
Fall 1995



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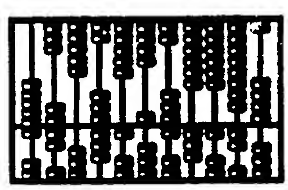

Interdepartmental Memorandum

Mail Station L-728 — Employee Development Division

Ext: 4-5482 — 6/12/95

TO: Teaching Credential Candidates

FROM: **Dorothy Freeman (2-4702) and Lisa Swayne (4-5482)**

Attached is the application package for the Teaching Credential Program for which you have expressed an interest.

Here's a breakdown of what is included in this packet:

- San Jose State University Teaching Credential Program Application and Information Packet
- LLNL Teaching Credential Plan
- LLNL Teaching Credential Program Approval Form
- LLNL Promissory Note (to be used if tuition advancement is desired)
- Teaching Credential Program Application Checklist

Academic Programs Group is hoping to get a new class started during Fall of 1995. To make the application process as convenient as possible, we ask that you return all forms to the Academic Program Office at L-728 by June 30, 1995, (see Application Instructions, enclosed). Your transcripts and letters of reference can also be sent directly to us. We will forward them on to SJSU. There may be more applicants for this program than there are openings in the class. One of the selection criteria will be when your application packet is complete. (We intend to date stamp the material upon completion.)

Please be aware that this program is being administered in the same manner financially as any other educational reimbursement programs here at LLNL. For instance, we can either advance the tuition to you through the use of the promissory note, or reimburse you upon completion of the class. Also, any non-tuition fees (such as those for the SJSU application, CBEST or other tests, transcripts, Certificate of Clearance) or expenses for books/materials are not covered under LLNL's educational reimbursement policy and are your responsibility. If you have questions about any of these issues, we would be glad to discuss them with you.

You'll notice when you complete the enclosed forms that we are asking you to think about where you would like to do your classroom observation/practice teaching initially, as well as how you are considering using your teaching credential over the longer term. Classroom observation begins in your first semester, with practice teaching starting in the second semester and continuing until the end of the program. We suggest you teach near your home, but keep in mind that Livermore can support only a limited number of practice teachers. Therefore, you are encouraged to consider other schools in the greater Livermore Valley, the S.F. Bay Area, Contra Costa County, or San Joaquin County.

Please contact the Academic Programs Group at extension should you have other questions about the teaching credential programs or these application procedures. We look forward to working with you!

University of California
Lawrence Livermore National Laboratory

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APPLICATION INSTRUCTIONS
Single Subject Credential Program in Mathematics
San Jose State University

Steps to Follow:

1. Complete this application packet and submit it to:
Employee Development Division , L-728

2. Pass the California Basic Educational Skills Test (CBEST). You must pass this test before beginning the second semester of your studies. Information about this test is available in the Employee Development Division office. Your scores on the test will be sent to you by mail. Make sure you submit the original card which shows your scores for each part of the test with your completed application.

3. Submit all college and university transcripts. Complete transcripts of all academic work taken after high school are required to process your application. You can arrange to have transcripts mailed directly to: Ms. Dorothy J. Freeman, Lawrence Livermore National Laboratory, P.O. Box 808, L728, Livermore, California, 94550. Transcripts must be official (no photo copies) and must arrive unopened. Unofficial transcripts will suffice for preliminary meetings with your mathematics education advisor (see #4, below).

4. Contact and meet with the mathematics education credential advisor. California law requires that you be certified "subject-matter competent" before you can be issued a credential. Your credential advisor will review your transcripts and other relevant documents to determine whether you have satisfied the subject matter competency requirement. This requirement consists of (1) a broad background in mathematics, with a minimum of good success in a minor in a mathematics, (2) content knowledge in mathematics as indicated by passing the National Teacher's Examination (NTE) in mathematics or by qualifying for the San Jose State University waiver in mathematics (a curriculum of specific courses or their equivalents), (3) evidence of appropriate professional aptitude for teaching to include communication skills and interpersonal relations, and (4) successful completion of the first semester of the program.

5. Obtain at least three letters of recommendation. Letters of recommendation should speak to your suitability and potential for teaching and should come from teachers, employers, and other non-family members who know you well. You may turn in these letters with your completed application documents or they may be mailed separately to Ms. Dorothy J. Freeman at the address above (see #3).

6. Submit a typed résumé. Make sure your résumé includes a list of all colleges and universities you attended after high school, a complete summary of your work experience, honors and awards, and anything else relevant to your career as a professional educator.

7. Submit a typed statement approximately 500 words in length of your reasons for pursuing a teaching career. This statement should address your motivation for wanting to teach and why you are well suited for a career as a professional educator.

If you have questions about the application process or need more information about the Mathematics Single Subject Credential Program, contact Dr. Billie Risacher, Coordinator at SJSU at (408) 924-5137, Dr. Michael Katz, SJSU Director of Secondary Education, at (408) 924-3755, or Ms. Dorothy Freemen project coordinator at LLNL at (510) 422-4702.

PROGRAM INFORMATION AND CREDENTIAL REQUIREMENTS
Mathematics Single Subject Teaching Credential
San Jose State University

The California Single Subject Teaching Credential in Mathematics is a license to teach mathematics in a publi· secondary school.

Requirements for the Preliminary Credential

There are five basic requirements for the Single Subject Teaching Credential:

1. **A bachelor's degree from an accredited institution of higher learning.** The degree must be taken in a field other than professional education.
2. **A passing score on the California Basic Educational Skills Test (CBEST).** This examination is offered several times each year at locations throughout California. Information about this test is available in room 2331, Bldg. 571 (Employee Development Division, Academic Programs).
3. **Verification of subject matter competence.** Credential candidates must demonstrate competence in mathematics. See Application Instructions for more information. NOTE: a passing score on the NTE does not by itself verify subject matter competence. Additional courses may be required even though you have a passing score on the National Teacher's Examination. Your advisor will help you plan to establish subject matter competence in mathematics.
4. **A grade point average of at least 2.75 for all college and university work.**
5. **A completed program of professional preparation.** The basic program for a Preliminary Single Subject Teaching Credential in Mathematics includes the following:

Semester I (prerequisite for the professional preparation courses of semesters II, III and IV)		
Concepts in Mathematics	3 units	Secondary concepts from an advanced viewpoint, topics from higher mathematics, reasoning and problem solving, and philosophy of mathematics education.
Pre-professional Experience*	2 units	On-site observation of instruction and other school activities: an introduction to contemporary secondary schools with readings and discussions.
Semester II		
Secondary School Mathematics	3 units	The place and function of mathematics in secondary education, improvement and evaluation of instruction, and teaching secondary school mathematics.
Student Teaching I*	2 units	On-site observation, tutoring, and small-group instruction: an introduction to supervised classroom teaching.
Semester III		
Evaluation and Classroom Management	3 units	Assessment of learning; fundamentals of educational evaluation; tests and measurements. Managing student behavior; successful management practices; legal requirements and constraints.
Student Teaching II*	4 units	Supervised classroom teaching.
Semester IV		
Foundations of Secondary Education	3 units	Schools and a pluralistic society; teaching to diversity; emphasis on schools as democratic institutions.
Student Teaching III*	4 units	Advanced student teaching.

***Your student teaching assignments will be made for you. Do not contact a school or district office without the approval of your advisor.**

U.S. Constitution Requirement. You must pass an approved course or test on the U.S. Constitution to be eligible for a California teaching credential. Many courses in government, history and political science satisfy this requirement. An approved U.S. Constitution test is offered at SJSU through the Testing Office (408-924-5980). The fee for this test is approximately $15.00. Check with your advisor to determine whether you have met this requirement.

Program Length and GPA Requirement. This is a two-year, part-time program of studies. You may take longer to complete the program with the approval of your advisor. Failure to maintain a grade point average of 3.0 in professional education coursework may result in disqualification.

Certificate of Clearance. A Certificate of Clearance is required before you may begin student teaching (Student Teaching I). Applying for the Certificate entails a health check and a search of police records; prior conviction of a felony disqualifies a candidate from the credential program. If you are uncertain about your eligibility, contact the Director of Secondary Education immediately. A fee of $82.50 is charged for the Certificate of Clearance ($50.00 to the FBI and Department of Justice and $32.50 to the Commission on Teacher Credentialing credited toward the credential application fee.) Candidates who have previously obtained a California credential (e.g., an emergency credential), do not have to apply for the Certificate of Clearance; they must, however, file a copy of the credential in the office of Secondary Education.

Progress in the Program. Each student's progress in the program is continuously monitored by faculty in Secondary Education and in the subject matter departments. If your GPA falls below 3.0 after the first semester, you may be disqualified from the Program. Students whose GPA falls below 3.0 after two semesters are disqualified and will not be recommended for a credential. The student is primarily responsible for ensuring that requirements are satisfied. You are advised to check with your advisor regularly to ensure that nothing is being overlooked.

Clear Credential Requirements. The Single Subject Preliminary Teaching Credential expires five years from the date of issuance. During that time it can be converted to a Professional Clear Credential by satisfying four additional requirements:

1. Complete thirty semester units of upper division or graduate coursework beyond the Bachelor's Degree (including credential coursework). Upper division coursework you took before entering the program may count toward this requirement.
2. Complete an approved course in mainstreaming (recommended: EDSC 192).
3. Complete an approved course in health education for teachers (recommended: EDTE 190 or HS 194).
4. Provide evidence of computer competence (normally satisfied through required courses for the preliminary credential and work experience).

The Professional Clear Credential is valid for five years from date of issuance. See the California Professional Growth Manual for renewal requirements.

If your application to this Program is denied for what you believe are unfair reasons, contact the director of Secondary Education, Sweeney Hall 301 (tel. 408-924-3755) at SJSU for information about appeals and grievance procedures.

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

Single Subject Credential Program - Mathematics - SJSU
Subject Matter Competency

California law requires that you be certified "subject-matter competent" before you can be issued a credential. There are two options to establish your competency in mathematics: (1) by passing the National Teacher's Examination (NTE) in mathematics or (2) by qualifying for a state approved waiver in mathematics (a curriculum of specific courses or their equivalents). Your advisor will discuss these options with you at the initial interview and help you plan to accomplish one of the options.

Option 1: Passing the NTE.

The NTE is a standardized test developed by the California Commission on Teacher Credentialing and the Educational Testing Service. The test measures breadth of knowledge in mathematics and consists of two parts of approximately two hours each. One part is a multiple choice format, and the other is an open response format, where examinees construct their own answers to four questions. The open-ended portion of this test contains questions pertaining to mathematics teaching and learning as well as mathematics concepts. It is considered a difficult exam in that there is currently a high failure rate.

If you choose the NTE option, it is recommended that you take the test after the first semester in the program. The Concepts in Mathematics course and the Pre-professional Experience course will help you succeed in passing the NTE. If you do not pass after the first semester, the second semester will continue to prepare you to pass the NTE. You must pass the exam before beginning the third semester of the program. Sample test questions and test taking tips will be discussed during the first semester courses, and your credential advisor will help you plan appropriate date/s for taking the exam.

The NTE is offered several times a year at various locations. An information booklet is available from the LLNL Academic Programs Office (extension 45479), or by writing :

NTE Programs
Educational Testing Service
P.O. Box 6051
Princeton, NJ 08541-6051 (Phone: 609-771-7395)

Option 2: Obtaining a state approved waiver

The State of California recognizes a list of specific university courses as sufficient to demonstrate competency in mathematics for a single subject teaching credential. The SJSU Waiver includes courses over broad range of mathematics topics. It is common that even a mathematics major does not qualify for this waiver without very careful planning early in their program of studies. Most persons choosing this option have several additional courses to take in order to satisfy the waiver.

Your advisor will review your transcripts and advise whether this option is a reasonable choice for you. A realistic plan to compete the needed courses is necessary to proceed in the program. Most of the course work will have to be completed before the beginning of the third semester of the program, as the demands of student teaching allow little time for taking additional mathematics courses. These courses may be taken at other universities and you may seek a waiver from another state university.

The SJSU Waiver includes 45 units consisting of the following:

Courses	Units
Math 30, 31, 32 (calculus)	10
Math 45 or 46A (computer programming)	3-4
Math 104: History of Mathematics	3
Math 115: Modern Geometry and Transformations	3
Math 126: Theory of Numbers	3
Math 128A or 129A (abstract algebra)	3
Math 112B or 131A or 133A (advanced calculus introductory analysis, differential equations)	3
Math 161 or 164 (statistics)	3
Math 162 or 163 or 142 (probability, probability theory numerical analysis)	3
Physics 50 and 51 or 52 (physics)	8
Upper Division Elective (abstract algebra, topology, linear algebra, real variables)	3

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Applicant Information Form
Single Subject Credential Program
Mathematics
San Jose State University

Application for: Fall 19____ Spring 19___

Name______ ______________________________ SSN:____________________
Last First

Address:______________________________ City________________________

State______ Zip___________ Telephone(s)________________________________

Current position at Lawrence Livermore National Lab.______________________________

Office address_______________________________Office telephone #____________

Have you been granted a teaching credential previously? Yes(√)_____ No(√)_____

Credential Name/Type____________________State_____ Expiration
Date_________

List the colleges/universities you have attended beginning with the most recent.

Institution	Dates	Major	GPA	Degree
1.				
2.				
3.				

Have you passed CBEST? Yes___ No___ Total Score_____ Exam Date_______________

Have you passed a college level course or test on the U.S. Constitution? Yes(√)_____ No(√)_____

Institution______________ Course No. ______ Test_____ Date____________

Applicant's Statement: I certify that the information given here is accurate to the best of my knowledge.

Signature________________________________ Date____________________

Subject Matter Competency Report
Single Subject Credential Program
San Jose State University

Instructions: Complete only the part above the dotted line. Meet with your mathematics education advisor to complete the parts below the dotted line. Attach transcripts.

Name ______________________ SSN ______________________

Address ______________________ City ____________ State ____ Zip______

Telephone ______________________ Teach. Subject Area ______________________

Degree ______ Date Awarded __________ Institution ______________ GPA _____

Plan A. Waiver Program. Courses required (prefix, title, semester to be taken):

1. ____
2. ____
3. ____
4. ____

Plan B. Examination. NTE test date ________ Standard Score ________

NTE must be passed before third semester. Additional Courses Recommended:

1. ______________________ 2. ______________________

3. ______________________ 4. ______________________

Additional NTE test date __________ Standard Score __________

Additional NTE test date __________ Standard Score __________

Interview: Date ____________ Interview Passed __________

Assessment Completed: Yes ________ No ________

Recommendation: Admit ______ Defer ______ Deny ______

Admit Conditionally ______ Fall ______ Spring ______

Comments/restrictions/conditions:

Advisor ______________________________ Date ______________

SECONDARY EDUCATION APPROVAL REQUEST
Single Subject Credential Program - Mathematics
San Jose State University

Instructions: Complete only the part above the dotted line. The bottom portion will be completed when you meet with your advisor. Please print.

Name______________________________ SSN______________
Last First

Address______________________________ City______________

State__________ Zip____________ Telephone(s)______________________

GPA for all college and university work__________

- -

Completed application materials (√):

____ Applicant Information Form

____ CBEST card with scores (if taken)

____ Subject Matter Competency Report

____ Letters of recommendation (3)

____ Transcripts (all college and university)

____ Statement of reasons for pursuing teaching as a career

____ NTE scores (if required)

____ Current resume

Recommendation (√):

Admit to program: Fall (√)____ Spring (√)____ 199__ Defer____ Deny____

Comment/reasons for recommendation:

Director of Secondary Education______________________ Date____________

db/EDSC/11-10-92

Teaching Credential Program
Application Checklist

The following items are required for the initial application.

______ SJSU Application Information Form

______ College /University transcripts from:

____

____

____

____

____

______ Resume

______ Statement of Purpose

______ Letters of Reference (at least three are required):

____

____

____

____

____

____

APPLICATION AND INFORMATION PACKET
1995 - 96

Single Subject Credential Program
San Jose State University

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

College of Education • Division of Teacher Education
Bilingual Education • Child Development • Elementary Education • Secondary Education
One Washington Square • San José, California 95192-0074

Dear Applicant:

Thank you for your interest in the Single Subject Teaching Credential program at San Jose State University. This packet of materials contains the information and forms you need to begin the application process. Please read it very carefully. The Application Instructions on the following pages will help you in gathering the appropriate documentation for your application.

No final action will be taken on your application until you have submitted the following materials:

1) the original card showing your CBEST scores;
2) a subject matter competency form signed by a subject area advisor;
3) the pre-professional experience form;
4) a program planning guide signed by a secondary education advisor.

Remember: you must complete separate applications to the Single Subject Credential Program and the University.

If you need further information, please contact the Student Information/Credential Preparation Center in Sweeney Hall 108 or call that office at 408-924-3608. All preliminary questions regarding the application process can be answered by the staff in that office.

In addition, voluntary, group advisement sessions are scheduled throughout the semester. These advisement sessions provide basic information regarding, but not limited to, the application process, CBEST, Certificate of Clearance, student teaching, preliminary/clear credential, and supplemental authorizations. Please contact the Student Information/Credential Preparation Center at 408-924-3608 for the times and places of these advisement sessions.

If you encounter a problem you cannot resolve, please contact me in the Office of Secondary Education, Sweeney Hall 305 or at 408-924-3755.

Welcome to San Jose State!

Cordially,

Robert Curley

Dr. Robert Curley, Director
Secondary Education

APPLICATION INSTRUCTIONS
Single Subject Credential Program
San Jose State University

Steps to Follow:

1. **Apply for admission to San Jose State University.** Applications for admission to the University are available at the Office of Admissions and Records in Wahlquist Library Central, at the corner of San Fernando and Fourth Streets (Tel. 408/ 924-2000). Note: you must apply for admission to the University as well as admission to the Single Subject Credential Program. Each of these separate applications requires a complete set of official transcripts (i.e., you will need two sets).

2. **Pass the California Basic Educational Skills test (CBEST).** This test consists of three parts; you must pass all three before you can be admitted to the credential program. Information about this test can be picked up at the Student Information/Credential Preparation Center, Sweeney Hall, Room 108. To have test information sent to you by mail, contact National Evaluation Systems, Inc. (916/928-4001). Several weeks after you have taken the test, you will receive the results by mail. The original card which shows your scores for each part of the test must be submitted with your completed application.

3. **Contact and meet with an advisor in the subject area (e.g., math, science, English, etc.) in which you intend to teach.** California law requires that you be certified "subject-matter competent" before you can be issued a credential. Your subject area credential advisor will review your transcripts and other relevant documents to determine whether you have satisfied the subject matter competency requirement. Take your transcripts and the "Subject Matter Competency Clearance" form (included in this packet) to that meeting. **A list of subject area advisors is included in this packet.** NOTE: A Subject Matter Competency Clearance form signed by a subject area advisor is required for admission to the credential program.

4. **Document your pre-professional experience.** The California Commission on Teacher Credentialing (CTC) requires a "pre-professional field experience" before you can be admitted to the credential program. This requirement can be satisfied by coursework (e.g. EDTE 166) or by having served in an instructional capacity in a public secondary school (e.g., middle school, junior high, or high school) classroom (e.g., teacher's aide, substitute) for at least 30 clock hours. Generally, experience in an elementary school, in a private or parochial school, or as a community college instructor does not satisfy the pre-professional experience requirement.

   Coursework is strongly preferred if you have the time to sign up for it in advance of your admission to the program. You can document thirty hours service by having the person who supervised your work sign in the space provided on the Pre-Professional Experience Verification form included in this packet. Consult a Secondary Education or Teaching Subject Area advisor about how to best satisfy this requirement. NOTE: This requirement is a prerequisite to entering the program.

5. **Obtain at least three letters of recommendation.** Letters of recommendation should speak to your suitability and potential for teaching, and should come from teachers, employers, and other non-family members who know you well. You may turn in these letters with your completed application documents or they may be mailed separately to Dr. Robert Curley, Director, Secondary Education, College of Education, San Jose State University, One Washington Square, San Jose, CA, 95192-0074.

6. **Submit a typed resume.** Make sure your resume includes a list of all colleges and universities you attended after high school, a complete summary of your work experience, honors and awards, and anything else relevant to your career as a professional educator.

7. **Submit a typed statement approximately 250 - 500 words in length of your reasons for pursuing a teaching career.** This statement should address your motivation for wanting to teach and why you are well suited for a career as a professional educator.

8. **Contact and meet with a Secondary Education advisor.** The purpose of this meeting is to review your application materials and to plan your credential coursework. This advisor will want to see your CBEST scores, the Pre-Professional Field Experience Verification, transcripts, the Subject Matter Competency Report, PRAXIS scores (if required by your Teaching Subject Area advisor), letters of recommendation, your resume and your statement of reasons for pursuing teaching as a career. Your Secondary Education advisor will sign your Teacher Education Approval Request form (included in this packet) and will fill out with you the Program Planning Guide (supplied by your advisor at the time of your meeting).

9. **Turn in your completed application materials.** The last page of this packet, The Secondary Education Approval Request, contains a check list of the documents you need to turn in. Refer to it to ensure that nothing has been overlooked, and then submit your application to the Office of Secondary Education, SH 305, or to the Student Information/Credential Preparation Center, Sweeney Hall, Room 108. If you wish, you may mail your application to: Director of Secondary Education, College of Education, San Jose State University, One Washington Square, San Jose, CA 95192-0074. Your application materials will be reviewed and you will be notified by mail of your admission status.

If you have questions about the application process or need more information about the Single Subject Credential Program, contact the Student Information/Credential Preparation Center at 408/924-3608, or contact an advisor (see lists of advisors included in this packet).

APPLICATION DEADLINES:

All applications for Spring 1996 semester should be completed by December 1, 1995. Deadlines may be extended by subject area advisors.

jnEDSC10/95

PROGRAM INFORMATION AND CREDENTIAL REQUIREMENTS
Single Subject Credential
San Jose State University

The California Single Subject Teaching Credential is a license to teach specific subjects in California public schools. If you want to teach a specific secondary school subject you will need a Single Subject Teaching Credential.

Requirements for the Credential. There are six basic requirements for the Single Subject Credential:

1. **A bachelor's degree from an accredited institution of higher learning.** The degree must be taken in a field other than professional education.
2. **A passing score on the California Basic Educational Skills Test (CBEST).** This examination is offered several times each year at convenient locations throughout California. Information about this test is available in the Credentials Office (Sweeney Hall 108; telephone 408-924-3608)
3. **Verification of subject matter competence.** Credential candidates must demonstrate competence in the subject(s) they intend to teach. Competence can be demonstrated in either of two ways: (a) complete an approved "waiver" program of studies in the subject you want to teach or (b) pass the PRAXIS and/or the SSAT (Single Subject Achievement Test) in specialty area. NOTE: *A passing score on either test does not by itself verify subject matter competence.* Additional courses may be required. Candidates must meet with a Subject Area Advisor to determine which examinations to take.

   San Jose State University offers approved "waiver" programs in the following areas:

   - Art
   - Business
   - English (including ESL, Communication Studies, Humanities, Journalism, and Theatre Arts)
   - Foreign Languages
   - Health Science
   - Industrial Arts
   - Life Science
   - Mathematics
   - Music
   - Physical Education
   - Physical Science
   - Social Science (including History and Government)

An advisor in your teaching subject matter area will help you establish subject matter competence.

4. **A grade point average of approximately 2.75 for all college and university work.** In some subject matter areas, the gpa requirement is somewhat higher, and in others, slightly lower. Check with an advisor for the exact requirement in your teaching area.
5. **A completed program of professional preparation.** Professional preparation varies somewhat depending upon teaching subject matter, previous college work, and other related experience in education. The basic program for a Preliminary Single Subject Credential includes the following:

EDSC 172	Socio-Humanistic Foundations of Secondary Education	3 units
EDSC 173	Psychological Foundations of Secondary Education	3 units
EDSC 184X	Student Teaching I	4 units
EDSC 138A	Reading in the Content Areas	3 units
EDSC 182	Evaluation	2 units
**Educ. ___	Methods	3 units
**Educ. 184Y	Student Teaching II	4 units
**Educ. 184Z	Student Teaching III	4 units

**Taken in the subject matter department of the candidate's teaching subject area

6. **U.S. Constitution Requirement.** You must have passed a course or approved test on the U.S. Constitution to be eligible for a California teaching credential. Check with an advisor in Secondary Education to ensure you have met this requirement.

Prerequisites. Applicants are required to meet the "pre-professional experience" requirement before beginning the professional preparation program. This requirement can be satisfied by coursework (e.g., EDTE 166) or by serving at least thirty supervised clock hours in an instructional setting in a secondary school classroom (e.g., substituting, teacher's aide). You must also have passed CBEST and been reviewed by a subject area advisor for subject matter competence. Check with a Secondary Education or subject area advisor to determine how you can best satisfy these requirements.

Program Length and GPA Requirement. Most students complete the professional preparation credential requirements in two semesters full-time study. You may, however, take more than two semesters to complete the program. In either case, failure to maintain a grade point average of 3.0 in professional education coursework may result in disqualification.

Student Teaching. Student teaching occurs in two phases and normally begins in the first semester of study. In most cases, Phase I Student Teaching (EDSC 184X) is taken in conjunction with EDSC 172 and EDSC 173. These three courses are known as the "Ed Bloc." Phase II Student Teaching is taken in the subject matter department which corresponds to the candidate's teaching subject area. Single Subject Credential Candidates in Science, for example, take Phase II Student Teaching in the Department of Science.

Certificate of Clearance. A Certificate of Clearance is required before you may begin student teaching. Applying for the Certificate entails a health check and a search of police records; conviction of a felony disqualifies a candidate from the credential program. If you are uncertain about your eligibility, contact the Director of Secondary Education immediately. A fee of $91.00 is charged for the Certificate of Clearance ($56.00 to the FBI and Department of Justice and $35.00 to the Commission on Teacher Credentialing credited toward the credential application fee.) Candidates who have previously obtained a California credential (e.g., an emergency credential), do not have to apply for the Certificate of Clearance; they must, however, file a copy of the previous credential with the Student Information/Credential Preparation Center.

Progress in the Program. Each student's progress in the program is continuously monitored by faculty in Secondary Education and in the subject matter departments. If your gpa falls below 3.0 after the first semester, you may be disqualified from the Program. Students whose gpa falls below 3.0 after two semesters are disqualified and will not be recommended for a credential. The student is ultimately responsible for ensuring that requirements are satisfied. You are advised to check with your advisors regularly to ensure that nothing is being overlooked.

Clear Credential Requirements. The Single Subject Preliminary Teaching Credential expires five years from the date of issuance. During that time it can be converted to a Professional Clear Credential by satisfying five additional requirements:

1. Complete thirty semester units of upper division or graduate coursework beyond the Bachelor's Degree (including credential coursework).
2. Complete an approved course in mainstreaming (recommended: EDSE 192).
3. Complete an approved course in health education for teachers (recommended: EDTE 190 or HS 194).
4. Provide evidence of computer competence (in some subject areas satisfied through required courses for the preliminary credential; may include additional coursework such as EDIT 122).
5. Provide verification of training in cardiopulmondary resuscitation (CPR) which meets the standards set by the American Heart Association or the American Red Cross (recommended: The *Heartsaver* course of the American Heart Association or the *Community CPR* Course of the American Red Cross).

The Professional Clear Credential is valid for five years from date of issuance. See the California Professional Growth Manual for renewal requirements.

Grievance and Appeals. If your application to the Program or the University is denied for what you believe are unfair reasons, contact the director of Secondary Education, SH 305 (408-924-3755) for information about appeals and grievance procedures.

Teaching Subject Area Advisors
Single Subject Teaching Credential

Subject Area	Advisor	Office	Phone
Art	Dr. Pam Sharp El Shayeb (Leave S96)	A 211	924-4396
	Ms. Donna Thompson	A 211	924-4395
Business	Dr. David Bond	SH 421	924-3750
English	Dr. Judith Barnes (Comm. Studies)	HGH 112	924-5511
	Dr. Martha Bean (ESL)	A 141	924-4707
	Dr. Ken Blase (Journalism)	DBH 103	924-3240
	Dr. Beverly Crane* (English)	FO 117	924-4453
	Dr. Jonathan Lovell (English-Leave F95)	FO 109	924-4437
	Dr. Marianina Olcott (Humanities)	FO 118	924-4455
	Dr. Ethel Walker (Theatre Arts)	HGH 213	924-4586
Foreign Language	Dr. Carmen Sigler	SH 219	924-4602
Government, History	See Social Science		
Health Science	Dr. Dan Perales	MH 409	924-4695
Human Performance (P.E.)	Dr. Cathy Buell*	SPX 204A	924-3021
	Dr. Nancy Carleton	SPX 11	924-3042
Industrial Studies	Dr. David Holmes	IS 111	924-3190
	Dr. Joe Yabu*	IS 103	924-3207
Mathematics	Dr. Joanne Becker	MH 313	924-5112
	Dr. Randall Charles (Leave F95)	MH 419	924-5071
	Mr. Richard Kitchen	MH311	924-5157
	Dr. Barbara Pence*	MH 419	924-5142
	Dr. Billie Risacher	MH 217	924-5137
	Dr. Marilyn Ruch	MH208	924-5101
Music	Dr. Pablo Ferman	M 159	924-4636
	Dr. Rebecca Herrold*	M 109	924-4634
Science (Life and Physical)	Dr. Jean Beard*	DH 439	924-4870
	Dr. Jim Paolini	DH 451	924-4835
	Dr. Dan Walker	DH 438	924-4873
Social Science	Dr. Bill Hanna*	DMH 210	924-5541
	Dr. Patricia Hill	DMH 238A	924-5755
	Dr. Ivan Kolozsvari	DMH 240	924-5744
	Dr. Robert Kumamoto (Leave F95)	DHM 210	924-5740

* Lead Advisor

Secondary Education Advisors
Single Subject Teaching Credential

ADVISOR	Office	Phone
Dr. Roberta Ahlquist	SH 321	924-3735
Dr. David Bond	SH 421	924-3750
Dr. Robert Curley (Director)	SH 301	924-3755
Dr. Kathleen Densmore	SH 321	924-3744
Dr. Michael Katz	SH 341	924-3743

Applicant Information Form
Single Subject Credential Program
San Jose State University

Application for: Fall 19_____ Spring 19_____ Teaching Subject Area_______________________

Name____ SSN:_____________________
Last First

Address:_________________________________ City______________________________

State________ Zip______________ Home telephone(s)____________________________

Work telephone(s)____

Date Bachelor's Degree awarded or expected:_______________Institution:________________

Have you been granted a teaching credential previously? Yes(√)_____ No(√)______

Credential Name/Type___________________________State_______ Expiration Date___________

List the colleges/universities you have attended beginning with the most recent.

Institution Dates Major GPA Degree

1.____

2.____

3.____

4.____

Have you passed CBEST? Yes___ No____ Total Score_______ Exam Date__________________

Have you passed a college level course or test on the U.S. Constitution? Yes(√)_____ No(√)______

Institution___________________ Course No. ________ Test_______ Date______________

Applicant's Statement: I certify that the information given here is accurate to the best of my knowledge.

Signature____ Date_______________________

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Pre-Professional Experience Verification
Single Subject Credential Program
San Jose State University

Name____ SSN:__________________
Last First M.I.

1. In the space below, list the course(s) you have taken, if any, which may satisfy the pre-professional experience requirement (e.g., EDTE 166).

Course #	Course Title	Institution	When Taken	Grade

2. Describe the position(s) you held or service you provided (e.g., teacher's aide, substitute) in which you were required to work with students in a secondary school. This experience can be documented by having the person who supervised your work (1) sign below under **Supervisor Verification** or (2) send a letter of verification to Director of Secondary Education, College of Education, San Jose State University, One Washington Square, San Jose, CA, 95192-0074.

Title of Position	Institution or Organization	Responsibilities or Duties	Dates

Supervisor Verification: I (print name)________________________________verify that the above named applicant to the SJSU Single Subject Credential Program served in an instructional/aide capacity for a minimum of thirty hours from (dates)________________ to ____________________ at (institution)____.

Supervisor Signature____ Date__________________

Position____ Telephone ____________________________

To the best of my knowledge, the above information is accurate.

____ ______________________________
Applicant Signature Date

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Subject Matter Competency Report
Single Subject Credential Program
San Jose State University

Instructions: Complete only the part above the dotted line. Meet with your teaching subject area advisor to complete the parts below the dotted line. Attach transcripts.

Name ____________________ SSN ____________________

Address ____________________ City ____________ State ______ Zip ________

Telephone ____________________ Teach. Subject Area ____________________

Degree ________ Date Awarded ____________ Institution ____________________ GPA ________

Plan A. Waiver Program. Courses Required (prefix, title, semester to be taken):

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Plan B. Examination. PRAXIS exam date ____________ Standard Score (s) ____________

Additional Courses Required:

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________

Interview: √ Required ☐ Interview passed ☐ Interview date ____________

Assessment Completed: √ Yes ☐ No ☐

Recommendation: √ Admit ☐ Admit Conditionally * ☐ Fall ____ Spring ____ Defer ☐ Deny ☐

Comments:

Restrictions/Conditions:

Advisor ______________________________ Date ____________

*If recommendation is for conditional admission, please indicate specific restrictions/conditions that apply.

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SECONDARY EDUCATION APPROVAL REQUEST
Single Subject Credential Program
San Jose State University

Instructions: Complete only the part above the dotted line. The bottom portion will be completed when you meet with your advisor in Secondary Education. Please print.

Name______________________________________ SSN____________________
Last First

Address__________________________________ City______________________

State__________ Zip__________Telephone(s)______________________________

Teaching Subject Area__________________________ GPA (all college/university work)______

Completed application materials (√):

____ Applicant Information Form

____ CBEST card with scores

____ Pre-Professional Exp. Verification

____ Subject Matter Competency Report

____ PRAXIS scores (if required)

____ Transcripts (all college and university)

____ Current resume

____ Letters of recommendation (3)

____ Statement of reasons for pursuing teaching as a career

____ Program Planning Guide (signed by Secondary Education advisor)

Advisor recommendation (√):

Admit to Bloc: Fall (√)____ Spring (√)____ 199___ Defer_____ Deny____

Advisor comments:

Advisor Signature________________________________ Date__________________

Program Director Approval__________________________ Date__________________

rc/EDSC/10-3-94

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